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Feasibility Study for the K-Area Bingham Pump Outage Pit (643-1G)

by

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FEASIBILITY STUDY
FOR THE
K-AREA BINGHAM PUMP OUTAGE PIT(643-1G) (U)

Revision 1.1
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Prepared By:

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Feasibility Study
for the
K-Area Bingham Pump Outage Pit (643-1G) (U)

DISCLAIMER

Instructions for Replacing Revision 1.1 Change Pages
for the
K-Area BPOP FS Report

1. Replace the Revision 1 Cover Sheet and Spine with the new Revision 1.1 Cover Sheet and Spine.
2. Replace the Revision 1 Title Sheet and Disclaimer Sheet with the new Revision 1.1 Title Sheet and Disclaimer Sheet.
3. Replace Revision 1 Table of Contents pages i through vii with new Revision 1.1 Table of Contents pages i through vii.
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ACRONYMS AND ABBREVIATIONS

ACL	Alternate Concentration Limit
ARAR	Applicable or Relevant and Appropriate Requirement
ASCAD™	Approved Standardized Corrective Action Design
bgs	Below Ground Surface
BPOP	Bingham Pump Outage Pit
BRA	Baseline Risk Assessment
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
Ci	Curie
COC	Constituent Of Concern
CSM	Conceptual Site Model
DCF	Dose Conversion Factor
DHEC	Department of Health and Environmental Control
DOE	U.S. Department of Energy
FFA	Federal Facility Agreement
FS	Feasibility Study
g/cm^3	Grams per Cubic Centimeter
HI	Hazard Index
HQ	Hazard Quotient
KBPOP	K-Area Bingham Pump Outage Pit
K_{OC}	Organic carbon partition coefficient
K_{OW}	Octanol/water partition coefficient
NPL	National Priorities List
O&M	Operation and Maintenance
pCi	Picocurie

pCi/g	Picocuries/gram
OSHA	Occupational Safety and Health Administration
POTW	Publicly-Owned Treatment Works
RAO	Remedial Action Objectives
RfD	Reference Dose
RGO	Remedial Goal Option
RI	Remedial Investigation
SCDHEC	South Carolina Department of Health and Environmental Control
SDCF	Soil/Debris Consolidation Facility
SRS	Savannah River Site
S/S	Solidification/Stabilization
SVOC	Semivolatile Organic Compound
USEPA	U.S. Environmental Protection Agency
WSRC	Westinghouse Savannah River Company

EXECUTIVE SUMMARY

This report presents the completed Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Feasibility Study (FS) of Remedial Alternatives for the K-Area Bingham Pump Outage Pit (KBPOP) at the Savannah River Site (SRS), South Carolina. This FS was developed in accordance with CERCLA guidance developed by the U.S. Environmental Protection Agency (USEPA).

The KBPOP is one of four BPOP areas at SRS. The KBPOP is designated as the lead unit in the BPOP Approved Standardized Corrective Action Design (ASCAD™) waste unit group. As the lead FS for all BPOPs in the BPOP ASCAD™ group, this document identifies potential technologies and process options for all BPOPs. The selected technologies and process options will form the basis for FSs conducted at all BPOPs. The development and screening of alternatives will also apply to all BPOPs in the waste group, while the detailed analysis of alternatives was conducted for the specific conditions at K-Area.

The K-Reactor is located in the west-central portion of SRS, approximately 4 miles east of the nearest SRS boundary. One pit exists at K-Area, situated immediately south and outside of the K-Reactor fence. The pit is approximately 400 feet long and 60 feet wide. The depth of excavation at KBPOP ranged from nine to 14 feet. Debris in the pit reportedly consists of miscellaneous construction materials such as pipes, cables, ladders, drums, and boxes of miscellaneous hardware. The KBPOP was backfilled with approximately four feet of fill material in 1958. The site is now an open grassy area and the pit boundaries are marked by orange ball markers and concrete monuments. Annual inspections are conducted for signs of soil subsidence, and sunken areas are filled to grade as needed.

The *Remedial Investigation* (RI) *Report With Baseline Risk Assessment* (BRA) *for the K-Area Bingham Pump Outage Pit* (WSRC-RP-95-1555, Rev. 1.2, WSRC 1997) concluded that minor concentrations/activities of constituents have migrated from the pit into the surrounding soil horizons; however, horizontal migration is limited to the boundaries of the pit and vertical migration is limited to the upper clayey zones. Geotechnical and geological data indicate that a less-permeable zone is present beneath the KBPOP that will inhibit less mobile constituents from migrating vertically and potentially impacting the groundwater. The RI/BRA concluded that the KBPOP has not impacted groundwater.

Remedial goal options (RGOs) were developed in the RI/BRA. Remedial goal options were not derived for groundwater. Although constituents were detected at levels exceeding appropriate risk values in the initial groundwater sampling round (samples bailed from temporary piezometers), they were not detected in the confirmatory sampling of permanent monitoring wells that were sampled using methodology designed to eliminate excess silt in the samples. Consequently, they are not considered to be contaminants of concern (COCs) in groundwater at the KBPOP. Based on these conclusions of the RI and BRA, remedial options for groundwater were not considered in this FS.

External exposure of hypothetical receptors to Cs-137 results in cancer risks of 1E-05 (residents) and 3E-06 (workers). Cs-137 in soil is likely ubiquitous at the K-Area due to global radioactive fallout and is believed not to be a risk driver.

A full range of general response actions were developed for all sites in the BPOP ASCAD™ waste unit group. The following general response actions were considered for the soils: No remedial action, institutional controls, containment, in-situ treatment, ex-situ treatment, and disposal. The following general response actions were considered for the groundwater: No remedial action, institutional controls, containment, recovery, treatment, and disposal. Technologies were identified within each general response action and screened on the basis of effectiveness, implementability, and cost.

Potential alternatives were developed from the list of retained technologies to address contaminated soils and groundwater at sites in the BPOP ASCAD™ waste unit group. Table ES-1 lists these alternatives.

The alternatives developed for the BPOP ASCAD™ waste unit group were screened for effectiveness, implementability, and relative cost. This screening was conducted on basis of data specific to the KBPOP. The results of the alternative screening are shown in Table ES-1 (alternatives for soil remediation) and Table ES-2 (alternatives for groundwater remediation). This screening resulted in the following alternatives being retained for soil and/or debris remediation at the KBPOP:

- No remedial action;
- Access and deed restrictions/notifications;
- Soil cover;
- In-situ solidification of soil and debris, soil cover;
- Excavate soil and debris, solidify/stabilize soil, backfill treated soil and debris, soil cover; and
- Excavate debris and soil, dispose in E-Area vaults or Soil/Debris Consolidation Facility (if applicable).

The RI concluded that the KBPOP is not impacting groundwater. Constituents were not observed to have migrated horizontally and clayey zones directly underneath the base of the pit would limit vertical migration potential. The data was interpreted to indicate that any leaching from KBPOP has not impacted the groundwater. Therefore, the only groundwater remedial alternative that was retained was the no-action alternative.

The six soil and/or debris remedial alternatives were screened on the basis of the USEPA's nine detailed screening criteria. These criteria are overall protection of human health and the environment; compliance with ARARs; long-term effectiveness and permanence; reduction of toxicity, mobility, and volume through treatment; short-term effectiveness; implementability; cost; state acceptance; and community acceptance. The results of this screening are shown in Table ES-3.

Table ES.1
Screening of Alternatives for Soil Remediation at the K-Area Bingham Pump Outage Pit, Savannah River Site, South Carolina

General Response/Alternative	Effectiveness	Implementability	Budgetary Cost[1]	Status
NO REMEDIAL ACTION				
1. No remedial action	Contamination reduced only through natural attenuation. Current risks are below 1E-4 level.	This alternative is technically and administratively implementable.	$280,000	Retained
INSTITUTIONAL CONTROLS				
2. Access and deed restrictions/ notifications	Provides protection for current and future human exposure for all soil pathways except fugitive dust. Provides limited protection for ecological exposure.	The site is currently the property of the Savannah River site. This alternative is technically and administratively implementable.	$300,000	Retained
CONTAINMENT				
3. Soil cover	Installation of a soil cover would provide protection for all current and future human exposure pathways as well as surface ecological pathways. Soil cover construction could produce limited worker exposure.	Soil covers are an established technology. This alternative is technically and administratively implementable.	$630,000	Retained

Table ES.1 (Continued)
Screening of Alternatives for Soil Remediation at the K-Area Bingham Pump Outage Pit, Savannah River Site, South Carolina

General Response/Alternative	Effectiveness	Implementability	Budgetary Cost	Status
4. Excavate debris and dispose at E-Area vaults or Soil Consolidation Facility, backfill and soil cover	Removal of debris will eliminate primary human and ecological exposure pathways. Residual soil contamination would remain at the site. Soil contamination levels are not considered significant. Installation of a soil cover would provide protection for all current and future human exposure pathways as well as surface ecological pathways.	This alternative is technically and administratively implementable.	$11,000,000	Eliminated
5. Excavate debris and dispose at Envirocare, backfill and soil cover	Removal of debris will eliminate primary human and ecological exposure pathways. Residual soil contamination would remain at the site. Soil contamination levels are not considered significant. Installation of a soil cover would provide protection for all current and future human exposure pathways as well as surface ecological pathways.	This alternative is technically and administratively implementable.	$11,000,000	Eliminated

Table ES.1 (Continued)
Screening of Alternatives for Soil Remediation at the K-Area Bingham Pump Outage Pit, Savannah River Site, South Carolina

General Response/Alternative	Effectiveness	Implementability	Budgetary Cost	Status
IN-SITU TREATMENT				
6. In-situ solidification of soil and debris, soil cover	Reduces mobility of contaminants. Provides protection for all exposure pathways. Debris may prevent complete treatment of all material. Treatment may produce worker exposures.	In-situ solidification/stabilization is an established technology. Special techniques may be necessary to grout through debris, but this alternative is otherwise technically and administratively implementable.	$2,000,000	Retained
7. Excavation of debris, debris disposal off unit, in-situ stabilization/solidification of soil, soil cover	Removal of debris will eliminate primary human and ecological exposure pathways. Residual soil contamination would remain at site. Soil contamination levels are not considered significant. Treatment of soils would reduce mobility of contaminants. Soil cover would provide additional protection for soil exposure pathways. Excavation may produce worker exposures.	This alternative is technically and administratively implementable.	$13,000,000	Eliminated
8. Excavation of debris and dispose off-unit; in-situ vitrification of soil; soil cover	In-situ vitrification is effective for treatment of contaminated soils. Reduces mobility of contaminants. Provides protection for all exposure pathways.	This alternative is technically and administratively implementable. However, vitrification has only limited establishment as a treatment technology. Technology availability and acceptance may reduce implementability.	$17,000,000	Eliminated

Table ES.1 (Continued)
Screening of Alternatives for Soil Remediation at the K-Area Bingham Pump Outage Pit, Savannah River Site, South Carolina

General Response/Alternative	Effectiveness	Implementability	Budgetary Cost	Status
EX-SITU TREATMENT				
9. Excavate debris and dispose off-unit, excavate soil and solidify/stabilize, backfill treated soil and soil cover	Removal of debris will eliminate primary human and ecological exposure pathways. Residual soil contamination would remain at site. Soil contamination levels are not considered significant. Treatment of soils would reduce mobility of contaminants. Soil cover would provide additional protection for soil exposure pathways. Excavation may produce worker exposures.	This alternative is technically and administratively implementable.	$13,000,000	Eliminated
10. Excavate debris and dispose off-unit, excavate soil and vitrify, backfill treated soil and soil cover	Removal of debris will eliminate primary human and ecological exposure pathways. Residual soil contamination would remain at site. Soil contamination levels are not considered significant. Treatment of soils would reduce mobility of contaminants. Soil cover would provide additional protection for soil exposure pathways. Excavation may produce worker exposures.	This alternative is technically and administratively implementable. However, vitrification has only limited establishment as a treatment technology. Technology availability and acceptance may reduce implementability.	$17,000,000	Eliminated

Table ES.1 (Continued)
Screening of Alternatives for Soil Remediation at the K-Area Bingham Pump Outage Pit, Savannah River Site, South Carolina

General Response/Alternative	Effectiveness	Implementability	Budgetary Cost	Status
11. Excavate soil and debris, solidify/ stabilize soil, backfill treated soil and debris, and soil cover	Residual soil and debris contamination would remain at site. Soil contamination levels are not considered significant. Treatment of soils would reduce mobility of contaminants. Soil cover would provide additional protection for soil exposure pathways and would provide some protection from contaminated debris. Excavation may produce worker exposures.	This alternative is technically and administratively implementable.	$3,400,000	Retained
OFF-UNIT DISPOSAL				
12. Excavation of debris and soil, disposal in E-Area Vaults or Soil Consolidation Facility, if applicable	Removal of soil and debris would eliminate human and ecological exposure pathways. Excavation may produce worker exposures.	This alternative is technically and administratively implementable.	$16,000,000[2]	Retained
13. Excavation of debris and soil, off-site disposal at Envirocare	Removal of debris and soils will eliminate human and ecological exposure pathways. Excavation may produce worker exposures.	Disposal at qualified landfills is an acceptable alternative. This alternative is technically and administratively implementable. SDCF disposal option is being developed/ evaluated in a separate alternatives study.	$21,000,000	Eliminated

[1] - Costs provided are preliminary estimates and should be considered comparative only. Costs are based on K-Area dimensions.

[2] - These costs are based on disposal in E-Area Vaults. The SDCF study will determine approximate costs for SDCF disposal option.

Note: Debris volume = 7,900 cubic yards. Soil volume = 5,250 cubic yards. Soil cover Area = 28,920 square feet (69 ft x 410 ft)

Table ES.2
Screening of Alternatives for Groundwater Remediation at the K-Area Bingham Pump Outage Pit, Savannah River Site, South Carolina

General Response/Alternative	Effectiveness	Implementability	Budgetary Cost[1]	Status
NO REMEDIAL ACTION				
1. No remedial action	Contamination would be reduced only through natural attenuation. Concentrations detected for contaminants with risks exceeding 1E-4 are suspect.	This alternative is technically and administratively implementable.	$0	Retained
INSTITUTIONAL CONTROLS				
2. Long-term monitoring	Provides protection by detecting changes in groundwater conditions.	Groundwater monitoring is implementable. This alternative is technically and administratively implementable.	$14,000/ sampling round[a]	Eliminated
3. ACL mixing zone	Contamination would be reduced only through natural attenuation. Concentrations detected for contaminants with risks exceeding 1E-4 are suspect. Action levels would be established and corrective action taken if the action levels are exceeded.	The site is currently the property of the Savannah River site. This alternative is technically and administratively implementable.	$290,000[b]	Eliminated
4. Access and deed restrictions	Provides protection for current and future exposure for all groundwater pathways. The BPOPs are located in established industrial zone areas.	The site is currently the property of the Savannah River site. However, the state owns the groundwater. This may impact the potential for use controls on the groundwater.	$330,000[c]	Eliminated

Table ES.2 (Continued)
Screening of Alternatives for Groundwater Remediation at the K-Area Bingham Pump Outage Pit, Savannah River Site, South Carolina (Continued)

General Response/Alternative	Effectiveness	Implementability	Budgetary Cost	Status
CONTAINMENT				
5. Soil cover	Installation of a soil cover would be effective for reducing the source of groundwater contamination from the site.	Soil covers are an established technology. This alternative is technically and administratively implementable.	$20 - $25/ Sq Ft plus $280,000 5-year reporting	Eliminated
6. Soil cover and slurry wall	In addition to reduction in source contamination, the exposure to groundwater would be limited through reduced contaminant mobility. A shallow continuous confining unit is necessary for slurry wall effectiveness	Slurry walls are an established technology. This alternative is technically and administratively implementable..	$20 - $25/ Sq Ft for soil cover plus $1000 - $1750/ linear ft for slurry wall plus $280,000 5-year reporting	Eliminated
TREATMENT				
7. Pump groundwater and treat by reverse osmosis	Reverse osmosis has been shown to be potentially effective for remediation of the groundwater contaminants identified for the site.	Reverse osmosis is an established treatment technology. This alternative is technically and administratively implementable.	$50,000 Site Prep plus $2,500,000 plus $0.005/ gallon plus $280,000 5-year reporting	Eliminated
8. Pump groundwater and treat by ion exchange	Ion exchange has been shown to be potentially effective for remediation of the groundwater contaminants identified for the site.	Ion exchange is an established treatment technology. This alternative is technically and administratively implementable.	$50,000 Site Prep plus $250,000 plus $0.05/ gallon plus $280,000 5-year reporting	Eliminated
9. Pump groundwater and treat by precipitation	Precipitation has been shown to be potentially effective for remediation of the groundwater contaminants identified for the site.	Precipitation is an established treatment technology. This alternative is technically and administratively implementable.	$50,000 Site Prep plus $2,000 plus $0.40/ gallon plus $280,000 5-year reporting	Eliminated

[1] - Costs provided are preliminary estimates and should be considered comparative only.
[a] - Assumes 6 wells sampled for metals, radionuclides, and semivolatiles. Includes field work, analytical and validation.
[b] - Assumes 160 hrs x $60/ hr plus 5 year reporting.
[c] - Includes Site maintenace and 5 year reporting.

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TABLE ES.3
COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES FOR SOIL CONTAMINATION
SAVANNAH RIVER SITE K AREA BPOP

Criteria	Alternative No. 1 No Action	Alternative No. 2 Access & Deed Restrictions	Alternative No. 3 Cap	Alternative No. 4 In-situ Solidification of soil; backfill treated soil and debris; soil cover	Alternative No. 5 Excavate soil and debris; solidification of soil; backfill treated soil and debris; soil cover	Alternative No. 6 Excavate soil and debris; dispose at E-Area vaults or consolidation facility, if applicable
OVERALL PROTECTIVENESS						
Human Health Protection	Provides same immediate protection as all other alternatives, but affords lower long-term protection due to possibility of cover or site development. Current risks are within EPA's acceptable limits.	Provides immediate protection through access restrictions; provides long-term protection through access and use restrictions.	Provides immediate and long term protection through elimination of exposure pathways.	Same as Alternative 3 except provides additional protection by solidification.	Same as Alternative 4.	Provides protection of human health by removing contaminated material.
Environmental Protection	Lowest degree of protection because cover erosion could result in contaminant exposure.	Greater long-term protection than Alternative 1 because site contact would be minimized.	More than Alternative 2 because soil cover would further reduce contact with contaminated material.	More than Alternative 3 because solidification would further reduce contact with contaminants.	Same as Alternative 4.	Provides protection of environment by removing contaminated material.
COMPLIANCE WITH ARARS						
Chemical-Specific ARARs	Not applicable; none identified.	Not applicable; none identified.	Not applicable; none identified.	Not applicable; none identified.	Not applicable; none identified.	Not applicable; none identified.
Location-Specific ARARs	Not applicable; none identified.	Not applicable; none identified.	Not applicable; none identified.	Not applicable; none identified.	Not applicable; none identified.	Not applicable; none identified.

TABLE ES.3- continued
COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES FOR SOIL CONTAMINATION
SAVANNAH RIVER SITE K AREA BPOP

Criteria	Alternative No. 1 No Action	Alternative No. 2 Access & Deed Restrictions	Alternative No. 3 Soil Cover	Alternative No. 4 In-situ Solidification of soil; backfill treated soil and debris; soil cover	Alternative No. 5 Excavate soil and debris; solidification of soil; backfill treated soil and debris; soil cover	Alternative No. 6 Excavate soil and debris; dispose at E-Area vaults or consolidation facility, if applicable
Action-Specific ARARs	None identified.	None Identified.	Meets all identified ARARS.	Meets all identified ARARS.	Meets all identified ARARS.	Meets all identified ARARS.
<u>LONG-TERM EFFECTIVENESS AND PERMANENCE</u>						
Magnitude of Residual Risk	Least reduction of all alternatives because no reduction would occur and threat could increase if site is not maintained. Current risk is within EPA's acceptable limits.	Slightly less than Alternative 1 because site would be maintained.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.	Greatest protection because all contaminated material is removed.
Adequacy and Reliability of Controls	No Controls.	Controls can prevent contact with contaminated media.	More reliable than Alternative 2.	More reliable than Alternative 3.	Same as Alternative 4.	Greatest reliability because all contaminated material is removed.
Need for 5-year Review	All Alternatives except 6 require 5 year review.	All Alternatives except 6 require 5 year review.	All Alternatives except 6 require 5 year review.	All Alternatives except 6 require 5 year review.	All Alternatives except 6 require 5 year review.	No review necessary because no waste would remain onsite.

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TABLE ES.3- continued
COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES FOR SOIL CONTAMINATION
SAVANNAH RIVER SITE K AREA BPOP

Criteria	Alternative No. 1 No Action	Alternative No. 2 Access & Deed Restrictions	Alternative No. 3 Soil Cover	Alternative No. 4 In-situ Solidification of soil; backfill treated soil and debris; soil cover	Alternative No. 5 Excavate soil and debris; solidification of soil; backfill treated soil and debris; soil cover	Alternative No. 6 Excavate soil and debris; dispose at E-Area vaults or consolidation facility, if applicable
REDUCTION OF TOXICITY, MOBILITY AND VOLUME THROUGH TREATMENT						
Treatment Process Used	None.	None.	None.	Directly treats inorganic contaminants.	Directly treats inorganic contaminants.	None.
Amount Destroyed or Treated	None.	None.	None.	Treats all inorganics within site, but total mass of organics remains the same.	Treats all inorganics within site, but total mass of organics remains the same.	None.
Reduction of Toxicity, Mobility, or Volume	None.	None.	Mobility of contaminants is reduced by soil cover.	Volume of contaminated material would be increased by up to 100% of the original volume, mobility of contaminants would be less than under Alternative 3.	Same as Alternative 4, except debris would not be treated by solidification.	None.
Irreversible Treatment	Not applicable, no treatment.	Not applicable, no treatment.	Not applicable, no treatment.	No further remedies could be undertaken on the treated material.	Same as Alternative 4.	Material would be removed.

TABLE ES.3- continued
COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES FOR SOIL CONTAMINATION
SAVANNAH RIVER SITE K AREA BPOP

Criteria	Alternative No. 1 No Action	Alternative No. 2 Access & Deed Restrictions	Alternative No. 3 Soil Cover	Alternative No. 4 In-situ Solidification of soil; backfill treated soil and debris; soil cover	Alternative No. 5 Excavate soil and debris; solidification of soil; backfill treated soil and debris; soil cover	Alternative No. 6 Excavate soil and debris; dispose at E-Area vaults or consolidation facility, if applicable
Type and Quantity of Residuals Remaining after Treatment	Not applicable, no treatment.	Not applicable, no treatment.	Not applicable, no treatment.	Same remaining residuals as Alternatives 1 through 3, but volume would increase and residuals would be solidified.	Same as Alternative 4.	Not applicable, no treatment.
SHORT-TERM EFFECTIVENESS						
Community Protection	No threat to community during implementation.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.
Worker Protection	No threat of exposure to workers.	Same as Alternative 1.	Same as Alternative 1.	Greater threat than Alternatives 1, 2 and 3 because treatment would require limited contact with contaminated materials.	Greater threat than Alternative 4 because treatment would require excavation of contaminated material.	Same as Alternative 5.
Environmental Impacts	No environmental threat during implementation.	Same as Alternative 1.	Same as Alternative 1.	Slight environmental threat because of limited contact with contaminated materials.	Greater threat than Alternative 4 because treatment would require excavation of contaminated material.	Same as Alternative 5.

TABLE ES.3- continued
COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES FOR SOIL CONTAMINATION
SAVANNAH RIVER SITE K AREA BPOP

Criteria	Alternative No. 1 No Action	Alternative No. 2 Access & Deed Restrictions	Alternative No. 3 Soil Cover	Alternative No. 4 In-situ Solidification of soil; backfill treated soil and debris; soil cover	Alternative No. 5 Excavate soil and debris; solidification of soil; backfill treated soil and debris; soil cover	Alternative No. 6 Excavate soil and debris; dispose at E-Area vaults or consolidation facility, if applicable
Time Until Action is Complete	Immediate.	Immediate.	Immediately effective, but onsite action would require 1 to 2 months after remedial design and contractor selection.	Immediately effective, but onsite action would require 2 to 3 months after remedial design and contractor selection.	Immediately effective, but onsite action would require 2 to 3 months after remedial design and contractor selection.	Immediately effective, but onsite action would require 2 to 3 months after remedial design and contractor selection.
<u>IMPLEMENTABILITY</u>						
Ability to Construct and Operate	No construction or operation.	Same as Alternative 1.	Simple to construct and maintain.	More difficult than Alternative 3 because special equipment is required for treatment.	Similar to Alternative 4.	Requires regulatory evaluation and comparison to waste acceptance criteria.
Ease of Doing More Action if Needed	Additional action easily implemented.	Same as Alternative 1.	Same as Alternative 1.	No further remedies could be undertaken on treated waste.	No further remedies could be undertaken on treated waste.	Contaminated material would be removed from site, so additional remedies would not be necessary.
Ability to Monitor Effectiveness	Alternative includes no monitoring; future exposure could occur in absence of controls.	Frequent inspection of property would provide notice of changes.	Same as Alternative 2.	Same as Alternative 2, except effectiveness of solidification would not be monitored.	Same as Alternative 2, except effectiveness of solidification would not be monitored.	No need to monitor because waste would not remain on site.

TABLE ES.3- continued
COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES FOR SOIL CONTAMINATION
SAVANNAH RIVER SITE K AREA BPOP

Criteria	Alternative No. 1 No Action	Alternative No. 2 Access & Deed Restrictions	Alternative No. 3 Soil Cover	Alternative No. 4 In-situ Solidification of soil; backfill treated soil and debris; soil cover	Alternative No. 5 Excavate soil and dcbris; solidification of soil; backfill treated soil and debris; soil cover	Alternative No. 6 Excavate soil and debris; dispose at E-Area vaults or consolidation facility, if applicable
Availability of Services and Equipment	No services or equipment needed.	Services are available locally.	Services and equipment are available.	Less than Alternative 3, longer lead time may be needed to secure services and equipment.	Same as Alternative 4.	Same as Alternative 4.
<u>COST</u>						
Capital Cost	$0	$21,000 - $31,000	$290,000 - $330,000	$1,800,000 - $2,600,000	$2,000,000 - $3,300,000	$16,000,000 - $17,000000
First Year Annual O&M Cost	$0	$1,600 - $1,700	$2,600	$2,600	$2,600	$0
Present Worth	$280,000	$320,000 - $330,000	$600,000 - $640,000	$2,100,000 - $2,900,000	$2,300,000 - $3,600,000	$16,000,000 - $17,000,000

SECTION 1
INTRODUCTION

The K-Area Bingham Pump Outage Pit (KBPOP) is one of four BPOP areas at Savannah River Site (SRS), collectively referred to as the BPOP waste unit group. This Feasibility Study (FS) of Remedial Alternatives serves as the lead FS for the BPOP waste unit group. This section identifies the purpose and scope of the FS and presents site background information summarized from the *Final Remedial Investigation Report with Baseline Risk Assessment* (RI/BRA) *WSRC-RP-95-1555, Rev. 1.2* (WSRC 1997).

1.1 PURPOSE AND SCOPE

The purpose of this FS is to identify potential technologies and process options for remediation of soil and groundwater contamination at the KBPOP, screen the technologies and options, and assemble the remaining technologies and options into remedial alternatives. The remedial alternatives are then evaluated on the basis of technical feasibility, effectiveness, and relative cost. The *Savannah River Site Community Relations Plan* (WSRC-RP-96-00120, Revision 1, July 1996) will be followed during the development of remedial alternatives for the KBPOP and the BPOP ASCAD waste unit group.

The KBPOP is designated as the lead unit in the BPOP Approved Standardized Corrective Action Design (ASCAD™) waste unit group. The ASCAD™ process is discussed in further detail in Section 1.2.

As the lead FS for all BPOPs in the BPOP ASCAD™ group, this document identifies potential technologies and process options for all BPOPs. The selected technologies and process options will form the basis for FS's conducted at all BPOPs. The development and screening of alternatives will also apply to all BPOPs in the waste group, while the detailed analysis of alternatives will be conducted for the specific conditions at K-Area.

This document consists of the following sections:

- Section 1 - Introduction
  Presents the site background, including location, history, and current description. Also summarizes the nature and extent of contamination, contaminant fate and transport, and the baseline risk assessment summary from the RI Report (WSRC 1997).

- Section 2 - Identification and Screening of Technologies and Process Options
  Identifies potential remedial technologies and associated process options to address soil and groundwater contamination. Technologies and options are initially screened on the basis of relative effectiveness, implementability, and relative cost.
- Section 3 - Development and Screening of Alternatives
  Technologies and process options remaining after screening in Section 2 are assembled into remedial alternatives to address soil and groundwater contamination. The alternatives are then compared to one another and screened on relative effectiveness, implementability, and relative cost.
- Section 4 - Detailed Analysis of Alternatives
  The alternatives remaining after the screening in Section 3 are evaluated in detail.

1.2 APPROVED STANDARDIZED CORRECTIVE ACTION DESIGN

The purpose of the ASCAD™ process at SRS is to focus data collection on remedial technologies, eliminate/reduce redundant documentation, obtain/facilitate pre-approved remedial decisions, and standardize remedial designs. The ASCAD™ approach reduces time and costs for remediating waste units by grouping similar waste units, focusing characterization and technology development on waste unit groups, and providing standardized designs which are based on unit specific requirements.

Waste units are grouped based on similarities such as waste category, media, unit specifics, and generic remedies. Waste categories focus on the manner in which waste was applied to the environment (i.e., basins, pits, piles, process lines). Media similarities address the environmental media that have been impacted. Examples are soil, vegetation, sediment, and groundwater. Unit specifics include soil classification, lithology, and waste area/volume. Generic remedies identify the potential for similar waste units to apply the same or similar remediation strategy.

ASCAD™ is being applied to the BPOPs waste unit group in an effort to develop primary and secondary documentation models for SRS. This effort focuses on combining the remedial investigation (RI), baseline risk assessment (BRA), FS, proposed plan, and record of decision for the R-Area, P-Area, and L-Area BPOPs. This reduced documentation is based on definitive documentation provided for the BPOPs waste unit group by the KBPOP lead unit. The BPOPs serve as an ideal ASCAD™ waste unit group since all have similar histories and waste characteristics.

ASCAD™ provides for the complete characterization, technology evaluation, and remedial design of the KBPOP lead unit within the BPOP waste unit group. This is followed by a focused characterization, technology validation, and unit specific design for R, P, and L BPOPs secondary units. ASCAD™ then provides for streamlining the design development process and projects focused technologies for remedial action for the R, P, and L BPOPs based on the KBPOP lead unit

1.3 SITE BACKGROUND

The KBPOP is one of four BPOP areas at Savannah River Site (SRS). The BPOPs are located outside the fences of reactor areas K, L, P, and R, which are situated in the central part of SRS, as shown on Figure 1.1.

1.3.1 Site Location

The K-Reactor, shown on Figure 1.1, is located in the west-central portion of SRS, approximately 4 miles east of the nearest SRS boundary. The KBPOP, shown on Figure 1.2, is situated immediately south and outside of the K-Reactor fence. All BPOPs are located approximately 4.5 to 6.1 miles from the nearest site boundary.

1.3.2 Site History

Major modifications and repairs to the primary and secondary reactor cooling water systems were performed between 1957 and 1958 (Pekkala, et al. 1987). Debris generated by these repairs was buried in the KBPOP. The radioactive contamination was less than 25 mR/hr with no detected alpha activity (Pekkala, et al. 1987). Debris with radioactive contamination greater than 25 mR/hr was placed in the Burial Ground. The concentration of radioactivity buried in each BPOP is conservatively estimated at 1 Curie (Ci) (Pekkala, et al. 1987). Table 1.1 illustrates the estimated inventory of activity at the time of burial and as of December 31, 1995.

Savannah River Site was added to the National Priorities List (NPL) in December 1989, subjecting the site to the provisions of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). The U.S. Department of Energy (DOE) has negotiated a Federal Facility Agreement (FFA) with the U.S. Environmental Protection Agency (USEPA) and the South Carolina Department of Health and Environmental Control (SCDHEC) to coordinate cleanup activities at SRS under a single comprehensive strategy.

A RI was conducted at the K-Area BPOP in the following stages:

- Preliminary unit evaluation
- Unit Screening
- Unit Assessment

In addition, a confirmatory characterization was conducted in July 1996. The results of all investigations are detailed in the RI/BRA Report (WSRC 1997) and are summarized in the remainder of this section.

1.3.3 Current Site Description

The following description of the site is summarized from the RI/BRA Report (WSRC 1996). The reader is referred to that document for more complete information.

1.3.3.1 K-Area BPOP Description

One pit exists at K-Area, at the location shown on Figure 1.2. The pit is approximately 400 feet in length and 60 feet in width, as shown on Figure 1.3. The depth of excavation at KBPOP ranged from nine to 14 feet, which indicates a sloping pit base. Debris in the pit reportedly consists of miscellaneous construction materials such as pipes, cables, ladders, drums, and boxes of miscellaneous hardware. No pumps were buried and no liquid waste was disposed of in the KBPOP.

The KBPOP was backfilled with approximately four feet of fill material in 1958. The site is now an open grassy area and the pit boundaries are marked by RFI/RI orange ball markers and concrete monuments. A recent photograph of the site is shown as Figure 1.4. Annual inspections are conducted for signs of soil subsidence, and sunken areas are filled to grade as needed. Two monitoring wells were installed at the KBPOP for the July 1996 Confirmatory Sampling, which is discussed below in Section 1.4.

The other BPOPs follow the same physical unit characteristics and therefore, constitute a prime ASCAD™ study group. Section 1.2 detailed the ASCAD™ methodology and principal issues involved in the selection of the BPOPs for ASCAD™. Table 1.2 shows the physical similarities among all the BPOPs.

The KBPOP is currently the only BPOP clearly delineated within an industrial zone. The other BPOPs are positioned close to the boundaries and are subject to be incorporated as part of an industrial zone.

1.3.3.2 Meteorology

Generally, the SRS region has a temperate climate with short, mild winters and long, humid summers. Average precipitation is approximately 48 inches per year and occurs relatively evenly throughout the year. A more detailed discussion of regional meteorology is located in the *RI Work Plan for the K-Area Bingham Pump Outage Pit, WSRC-RP-91-1203, Revision 1* (WSRC, 1994), and *the SRS Environmental Report for 1994* (WSRC, 1995b).

1.3.3.3 Surface Water Hydrology

Surface water drainage ditches surround the KBPOP to the north, west, and south. These ditches provide a means for runoff water to be collected and redirected to reduce erosion. As depicted in Figure 1.2, the KBPOP is located on the west side of a small topographical high. Consequently, surface water drainage from other areas has little or no effect on the surface of KBPOP. Runoff, resulting solely from KBPOP, is collected in the surface water drainage ditches and channeled downgradient towards several small intermittent streams. These intermittent streams drain into Indian Grave Branch and Pen Branch. Figure 1.5 illustrates the surface water flow in the vicinity of the KBPOP.

1.3.3.4 Geology

The KBPOP is situated in the Tobacco Road formation. This formation extends from ground surface to a depth of 95 feet below ground surface (bgs) and is composed of dark red to tan, very fine to fine sandy clay and clayey sands with laminated tan and purple, silty, clayey very fine to medium sands.

Underlying the Tobacco Road formation is the Dry Branch Formation, extending from 95 to 136 ft bgs. The Dry Branch formation consists of laminated, tan, clayey, very fine to medium sands with thin lenses of pale green clay.

The Griffins Landing Member extends from 136 to 167 ft bgs. The Griffins consists of yellow to tan, faintly laminated, silty, clayey, very fine to coarse sands and tan to yellow marl with hard brown limestone fragments.

Next is the McBean Formation at 167 to 171 ft bgs, consisting of greenish-black, fine sandy clay. This is underlain by the Congaree formation at 171 to 288 ft bgs. The Congaree is composed of tan to yellow, very fine to medium sands with gray, slightly silty, medium to very coarse sands with thin, interbedded gray clays.

The first confining unit in the area is Confining Unit IIA-IIB (Green Clay), which can be distinguished in the logs at approximately 170 feet bgs. Confining Unit IIB_1-IIB_2 (Tan Clay) is not apparent in the P-25 logs and is suspected to be nonexistent or discontinuous in this area.

Figures 1.6 and 1.7 show the lithologic data collected from the CPT locations in cross sectional view. To the north and south of the pit, there is a 17- to 20-foot thick massive clay interval. The clay interval appears to thin to a thickness of about seven feet in the middle portion of the pit, beneath KBP-9. The massive clay interval grades into a mixed layer of clay, clayey sand, and sandy clay to the east of KBP-9. The base of the pit is imbedded into the massive clay to the north and south. The base of the pit is located above the clay interval along the middle of the pit's western side.

1.3.3.5 Hydrogeology

Water elevation measurements, collected in January 1995 from six groundwater sample locations, were used to define the direction and rate of groundwater flow at the KBPOP. The groundwater flow direction, shown on the potentiometric surface map (Figure 1.8) is to the south (referenced to true North) across the KBPOP.

The groundwater flow rate for the water table aquifer (Aquifer IIB_2) beneath the KBPOP was estimated using a hydraulic conductivity of 10 ft/day (Geraghty & Miller, Inc., 1990) and an effective porosity value of 20 percent (Killian et al., 1987). The flow rate estimate for groundwater beneath the KBPOP is approximately 91.25 ft/year.

1.3.3.6 Demographics

The SRS is located approximately 40 km (25 miles) southeast of Augusta, Georgia, and 32 km (20 miles) south of Aiken, South Carolina. According to 1990 census data (Rand McNally, 1992), the average population densities (people per square mile) for the surrounding South Carolina counties are 111 for Aiken County, 36 for Barnwell County, and 28 for Allendale County, and for the surrounding Georgia counties are 228 for Columbia, 524 for Richmond, 25 for Burke, and 21 for Screven. The population within an 80.5 km (50 mi) radius of SRS is 634,784.

The estimated population for the area in the year 2000 is projected to be 852,000 (Rand McNally, 1992). This estimate was calculated using the 1970 to 1980 population growth rate of each county in the 80.5 km (50 mi) radius, with the assumption that the same growth rate would continue in the future. The calculations assumed that the population would be constant for counties that had a negative population growth between 1970 and 1980.

Calibrated demographic data is available for the six-county area that provides 90 percent of the SRS work force. These are Aiken, Allendale, Bamberg and Barnwell counties in South Carolina and Columbia and Richmond counties in Georgia. The population in these six counties increased 13 percent between 1980 and 1990, from 376,000 to 425,607 and is expected to increase to 470,820 by the year 2000. A disproportionate share of the six county population increase was concentrated in Columbia County of Georgia. The population in this county increased more than 55 percent to 66,031 between 1980 and 1991.

1.3.3.7 Land Use

Less than 5 percent of existing land surrounding SRS is devoted to urban and other developed uses (DOE, 1990). Most of the urbanized development has occurred in and around the cities of Augusta, Georgia and Aiken, South Carolina. Agriculture accounts for 24 percent of total land use; forests, wetlands, water bodies, and unclassified land that is predominantly rural account for approximately 70 percent of total land use. A projected 2 percent increase in the development of urban land surrounding SRS is expected by the year 2000.

Less than 5 percent of SRS total land area is used by facilities engaged in the production of special nuclear materials. Reservoirs and ponds comprise approximately 13 sq km (5 sq mi) of SRS. The remainder areas, approximately 777+ sq km (300+sq mi), is undeveloped.

K-Reactor Area, including KBPOP, is located within a specified industrial zone as defined by the Citizens Advisory Board. All of the other BPOPs are located close to specified industrial zones and may be incorporated as part of the zones at a later time.

1.3.3.8 Description of the Environment

The ecology of the BPOP consists of a small, 0.5-acre, grassland plant community that is adjoined on three sides by pine forest and industrial areas associated with K-Area. Ecologically, the site is predominately terrestrial; no aquatic habitat or wetlands are present within 1,000 meters of the KBPOP. A drainage ditch lined with large rocks traverses the area. The grassland habitat probably supports insects and small mammals. Larger vertebrates such as raccoon and gallinaceous birds such as quail and wild turkey may occasionally forage or travel through this area. No threatened or endangered species have been identified on the site nor does this area provide critical habitat. A more detailed description of the flora and fauna present on the site is given in the RI/BRA Report (WSRC 1997).

1.4 NATURE AND EXTENT OF CONTAMINATION

This section summarizes the analytical results from the Unit Assessment Stage III groundwater sampling and Stage IV soil sampling, which were performed in January and February of 1995. This section also discusses Confirmatory Sampling conducted in July 1996.

1.4.1 Summary of Soil Contamination

The RI Report concluded that minor concentrations/activities of constituents have migrated from the pit into the surrounding soil horizons; however, horizontal migration is limited to the boundaries of the pit and vertical migration is limited to the upper clayey zones.

Only one constituent of concern (COC) was identified at the KBPOP. The RI/BRA concluded that Cs-137 in surface soil exhibits a cancer risk of 2E-06. Cs-137 in surface soil is likely ubiquitous at the K-Area due to global radioactive fallout and is believed not to be a risk driver.

1.4.2 Summary of Groundwater Contamination

The geotechnical and geological data indicate that a less-permeable zone is present beneath the KBPOP that will inhibit less mobile constituents from migrating vertically and potentially impacting the groundwater.

Although the concentrations of both arsenic and I-129 in groundwater result in derived risks greater than 1E-04, the presence of these constituents was not confirmed in the groundwater sample obtained using the methodology designed to eliminate excess silt in the samples. Given that the confirmatory sampling did not detect these constituents, neither arsenic or I-129 are considered COCs at the KBPOP.

The following are considered COCs in groundwater:

- bis(2-Ethylhexyl)phthalate;
- Manganese;
- Tritium;
- Ra-228;
- U-233/234; and
- U-238.

1.5 CONSTITUENT FATE AND TRANSPORT

This section discusses the fate and transport of COCs as defined by the BRA, summarized below in Section 1.6, and additional constituents resulting from the nature and extent of contamination investigation.

1.5.1 Potential Routes of Migration

Constituent migration is dependent upon three critical factors: 1) physical and chemical properties of the constituents, 2) transport processes, and 3) parameters of media through which the constituents migrate. The primary source of contamination at KBPOP is the buried waste. Leaching has been defined as the primary release mechanism and provides the initial movement of constituents from the pit into surrounding soil horizons. Dust and/or volatile emissions, a secondary release mechanism, could be transported via the air/wind and/or storm water runoff pathways to off unit locations.

The soil underneath KBPOP would constitute the secondary source of contamination, if impacted. For this secondary source, infiltration/percolation would provide the means for constituents to migrate vertically, potentially reaching the groundwater. Once constituents enter the groundwater system, movement away from the unit boundaries is certain. The extent of migration in the groundwater is dependent on the aquifer flow rates and physical and chemical properties of constituents. Groundwater contamination is represented as a pathway in the conceptual site model (CSM), shown in Figure 1.9.

Constituents of concern for groundwater at the KBPOP are semivolatile organic compounds (SVOCS), radionuclides, and metals. The COC in soil is a radionuclide.

1.5.2 Physical and Chemical Properties of the Constituents

Physical and chemical properties of a constituent provide information on the behavior of that constituent in varying media. The extent to which a constituent moves or is transported through the environment is referred to as mobility. Mobility of a constituent is based upon many types of chemical and physical interactions between the constituent and media it contacts. In addition, constituents undergo different degrees of degradation. The following physical and chemical properties of a constituent affect the mobility and degradation of chemical constituents:

- *Water solubility.* The maximum concentration of a constituent that will dissolve in pure water at a specific temperature and pH.
- *Vapor pressure and Henry's Law constant.* Two measures of chemical volatility.
- *Octanol/water partition coefficient (Kow).* Constituents with high log Kow values (i.e., greater than 4) are more likely to remain adsorbed to organic material rather than migrate to water.
- *Organic carbon partition coefficient (Koc).* Indicates the tendency of an organic constituent to be adsorbed to organic material in soils or sediments. A high Koc value indicates that a constituent has a strong tendency to bind to organic material in soil.
- *Density (mass per unit volume).* A physical parameter that controls the rate of constituent migration in the subsurface. If the density of the constituent is greater than that of water (greater than 1 g/cm^3), the constituent will tend to displace groundwater and sink until a less permeable barrier is encountered. A density less than that of water will tend to cause the constituent to float on top of the groundwater.

The fate and transport of metals and radionuclides, which are the chemical classes that include the COCs, are discussed below. Fate and transport of specific COPCs are discussed in the RI/BRA Report (WSRC 1997).

1.5.2.1 Metals

Assessing the mobility and persistence of metals in environmental media is complicated due to the many inorganic and organic complexes and salts they form. In addition, metals undergo a variety of processes in soils and water, which include hydrolysis, reduction, oxidation, and ion exchange. These reactions are highly dependent on factors such as pH, salinity, ionic strength, particle-surface reactions, and the presence of anions and natural organic acids (humics and fulvics).

Many metals are relatively insoluble either in metallic form or as inorganic complexes and salts; yet become soluble in the presence of organic acids and oxidizing conditions. An exception is mercury, which is not very soluble in water but will readily volatilize from water to air. Cation exchange of metals by soils and sediments is the dominant fate mechanism in natural systems.

The geotechnical report in the RI/BRA Report describes the soil content from 0-18 feet as having a high clay content. The depths from 18-61 feet were not targeted for geotechnical sampling; however, the CPT data shows a clay layer extending to deeper depths before becoming more sandy in composition at 61-68 feet. For some constituents, the potential for constituents to bind with clay particles is great and will result in an accumulation of constituents at this depth range. Little vertical migration will take place within these clayey zones.

The RI identified manganese as a COC for groundwater. In general, the unusually high metal concentrations encountered in the groundwater at the KBPOP are probably related to the method of sample collection utilized during characterization and probably do not constitute a problem in the groundwater. With elevated turbidity associated with the groundwater samples, metal analyses would be skewed based upon the amount of solids within a particular sample. Further evaluation shows that all of the metal constituents were detected in both upgradient and downgradient or only upgradient groundwater samples locations. This condition indicates that the KBPOP is not a source of metals.

1.5.2.2 Radionuclides and Radionuclide Indicators

As the soil horizons and groundwater system are typically inhomogeneous, variables (i.e., physical parameters of constituents) are only valid for the conditions of a specified system. If the conditions of that system change (i.e., geochemistry, mineralogy, pH, and redox potential), then the variables would be altered as a direct result. Some variables for radionuclides, such as half-life, are specific to the isotope and are not influenced by a changing environment.

The soils in the area of the KBPOP tend to have large fractions of silt and clay, up to 35 percent, indicating that there is a good probability that any constituents that are prone to adsorb onto a clay matrix will deposit on the clay particles in the KBPOP soils and have a limited migration potential. It is possible for these constituents to migrate to the groundwater via colloidal transport (i.e., colloidal precipitate or colloidal clay particles) and may influence the groundwater analyses if samples are unfiltered. Redox sensitivity may also influence the movement of constituents in the environment. Higher oxidation for radionuclides (and other nonradioactive metals) would tend to favor hydrolysis reactions. The hydrolyzed species would tend to precipitate in an environment with a pH of 5 or greater. The precipitated constituents would then be filtered out by the soil and incorporated into the soil matrix.

At the KBPOP, Cs-137 was defined as a COC in soil. Tritium, Ra-228, U-233/234, and U-238 were defined as COCs in the groundwater. Specific radionuclide isotopes, differed between the soils and groundwater analyses, indicating that radioactive constituents found in the groundwater are not the result of the KBPOP. Activity is probably due to naturally occurring radionuclides, sampling/analysis artifacts, and/or upgradient sources.

1.5.3 Constituent Migration

The CSM, as depicted in Figure 1.9, indicates how constituents at the KBPOP may migrate away from the source material. The primary release mechanism is leaching of constituents from the waste, caused by infiltration of precipitation from the surface. Infiltrating water moves downward, potentially carrying leached constituents to deeper soils and groundwater. The infiltration of water through the vadose zone is controlled by soil properties and composition. Contaminated soils also constitute a potential secondary source.

Minor concentrations of constituents in soil have migrated away from the KBPOP, predominately in a vertical direction. Constituents have either a decreasing concentration/activity with depth or have no traceable trending effect resulting in random detections (such as laboratory contaminants, sampling/analysis artifacts, or naturally occurring constituents which are strongly dependent on the composition of the matrix).

In the groundwater system, the presence of metals and several radionuclide constituents at concentrations/activities greater than MCLs/background are probably related to excessive turbidity in the groundwater samples and not to contamination from the KBPOP. This conclusion is based on the results of the Confirmatory Sampling. Two elements of this investigation indicate that constituents found in the groundwater (if not present due to sampling artifacts) are not related to the KBPOP:

- Upgradient groundwater samples detected many of the same constituents found in downgradient samples. This would indicate that the constituents are originating from another source upgradient of the KBPOP or other contributing factors (i.e., naturally occurring constituents). Again, for metals and a few radionuclides, an additional element is present. The sampling protocol for the collection of the groundwater samples could have induced the unusually high metal concentrations found in the samples and may not be related to a source at all.
- Constituents found in the soils and groundwater vary. If the constituents originated from the KBPOP, constituents found in the groundwater should also have been found in the soils. This was not typically the case at the KBPOP as illustrated by the radionuclide constituents. One contributing factor was the presence of a defined clay layer underneath the base of the pit. This zone extended vertically to a depth greater than twenty feet below ground surface.

The geotechnical report supports that COPCs with the potential to bind to clay particles (based upon fate and transport characteristics of the constituents) will be concentrated in this zone and will have limited movement vertically.

1.5.4 Constituent Fate and Transport Conclusions

In the RI/BRA, risk calculations were performed for leachable COCs that pass through the soil screening and are estimated to appear in groundwater within the next 1000 years. The two scenarios considered are the Future On-Unit Resident and the Future On-Unit Worker.

The cancer risk for I-129 leaching from soil to groundwater is approximately 10^{-5} for the Future On-Unit Resident and 10^{-6} for the Future On-Unit Worker. However these risks are based upon one J-qualified detection (0.203 pCi/gm) out of three soil samples analyzed, and the value is below the reported detection limit for I-129. I-129 is difficult to detect at these low levels of activity because of the "noise" associated with a gamma PHA scan. Also, the maximum detected activity of Cs-137 in the soil is 0.295 pCi/gm. Based upon ratios of important fission products from reactor assemblies, the minimum ratio of Cs-137 to I-129 is 2.22×10^{6}. Therefore, based upon this ratio and the maximum observed Cs-137 activity, the maximum I-129 activity expected should be less than 1.33×10^{-7} pCi/gm, which is well below the J-qualified value reported for I-129. Also, the soil leachability estimate is conservative and overestimates future groundwater concentrations. Therefore, the RI/BRA concluded that corrective action for I-129 is not warranted based upon the soil leachability analysis and I-129 is not a COC in soil.

1.6 BASELINE RISK ASSESSMENT SUMMARY

An exposure assessment was conducted to estimate the type and magnitude of exposures to the COCs at the KBPOP. The results of the exposure assessment were combined with toxicity information to characterize potential risk. Figure 1.9 illustrates the CSM and describes how constituents are transported and transferred to human receptors.

1.6.1 Potential Receptors and Exposure Pathways

The primary source of contamination from the KBPOP is the construction debris that was contaminated with low levels of radiation and buried in an unlined pit. Constituents may have been released from the debris into the surrounding soil. In turn, soil contamination may exist in the subsurface soil due to migration or in the groundwater due to infiltration and percolation. Potential contamination in the subsurface soil was assessed using a soil-to-groundwater leachability model. The primary media of concern for the human health risk evaluation, therefore, are:

- Surface Soil
- Subsurface Soil

- Groundwater

There is no wetland or surface water within 1000 meters of the KBPOP. Surface water and sediment are not considered to be impacted by any contamination at this waste unit and were not considered as potential media of concern.

Release mechanisms from the surface soil include fugitive dust generation and vegetation uptake. Volatilization was initially considered; however, since no volatiles were identified as COCs in the surface soils, this pathway was eliminated.

The following exposure routes and pathways are applicable to the receptors evaluated in the human health risk assessment. A graphical depiction of the human health CSM for the KBPOP is presented in Figure 1.9.

1. Known On-Unit Worker
   The known on-unit worker exposure scenario addresses risks to workers who visit the waste unit on an infrequent or occasional basis. A drinking water pathway is not credible for the known on-unit worker since shallow groundwater is not used as a source of drinking water at SRS and controls are in place to prevent consumption of groundwater in this area. The known on-unit worker is an adult who visits the waste unit to mow the grass, inspect the unit for signs of subsidence, and check the signs. Although only annual inspections are required, the SRS worker is assumed to visit the waste unit six times per year.

   The primary exposure pathways for evaluation relative to the known on-unit worker include exposure to contaminated surface soils (0-1 ft intervals) via the pathways of ingestion, inhalation, dermal contact and external gamma exposure.

2. Hypothetical On-unit Worker.
   The future on-unit worker exposure scenario addresses long-term risks to workers who could be exposed routinely to COPCs within an industrial site. The hypothetical future on-unit industrial worker is an adult who works in an industrial setting outside for eight hours per day.

   The primary exposure pathways for the hypothetical on-unit worker are the same as for a known on-unit worker; however, ingestion of, and dermal contact with, drinking water from contaminated sources was also included. These pathways are summarized as follows: (1) exposure to contaminated surface soils (0-1 ft intervals) via the pathways of ingestion, inhalation, and external gamma exposure; and (2) exposure to contaminated groundwater via ingestion and dermal contact.

3. Hypothetical On-unit Resident Adult and Child

   The hypothetical on-unit resident exposure scenario addresses long-term risks to individuals expected to have unrestricted use of the waste unit. It assumes that residents live on the waste unit and are exposed chronically, both indoors and outdoors, to unit constituents. The hypothetical on-unit resident includes adults and children who would potentially be exposed to all of the contaminated media. This scenario is consistent with regulatory guidance documents.

The primary pathways proposed for evaluation relative to the hypothetical on-unit resident (adult and child) include: (1) exposure to contaminated soils via the pathways of incidental ingestion, inhalation of windblown dust, external gamma exposure, dermal contact, and ingestion of home grown produce; and (2) exposure to groundwater via the pathways of ingestion, dermal contact, and inhalation of volatile constituents while showering.

1.6.2 Risk Characterization

Risk characterization compares estimated exposure with applicable toxicological or dose-response data. This comparison is used to determine whether the chemical concentrations detected in the environmental media at the KBPOP may be associated with adverse effects on the health of humans potentially exposed to site-related chemicals.

Constituents having a chemical-specific carcinogenic risk of at least 1E-06 are considered carcinogenic COCs. Constituents having a hazard quotient (HQ) of at least 0.1 and contibuting to a pathway having a hazard index (HI) greater than 1.0 are considered noncarcinogenic COCs.

1.6.2.1 Evaluation of Noncarcinogenic Hazards

The risk of adverse noncarcinogenic effects from chemical exposure is expressed in terms of the HQ. The HQ is the ratio of the estimated dose which a human receives to the estimated dose level believed to be safe, the reference dose (RfD). Chemical-specific HQs are summed both for environmental media and exposure pathways to derive the total HI.

If the HI value is less than 1.0, it is believed the potential for noncarcinogenic injury is low. If the HI exceeds 1.0, some risk of noncarcinogenic effects may exist. However, because most RfD values are derived in a conservative fashion, an HI value greater then 1.0 does not imply that an adverse effect will necessarily occur. The evaluation of noncarcinogenic risks presented here is based on chronic exposure.

The calculations of the HQ and HI are provided in the RI/BRA Report. HIs for the known on-unit worker and hypothetical on-unit worker were below 1, indicating that adverse effects are not expected to occur in these receptors. An HI above 1, however, was derived for the hypothetical on-unit residents (HI = 7). The HI was wholly the result of potential exposure to naturally-occurring inorganics in groundwater (arsenic, manganese). As discussed in Section 1.5.3, the elevated metals in groundwater were likely a sampling artifact (samples contained high amounts of silt) and were not present as a result of KBPOP contamination.

1.6.2.2 Evaluation of Carcinogenic Risks (Nonradionuclides)

The risk of cancer from exposure to a chemical is described in terms of the probability that an individual exposed for an entire lifetime will develop cancer. Risk estimates are presented as excess cancer risk per unit of population. For example, a risk estimate of 1E-04 is equivalent to one excess occurrence of cancer per 10,000 exposed individuals in a given population.

Calculated risk estimates are provided in the RI/BRA Report. Cancer risks for the known on-unit worker were below the EPA target range of 1E-06 to 1E-04, indicating that an excess risk of cancer is not expected in this receptor.

The derived cancer risks for the hypothetical on-unit workers (8E-05) and residents (3E-04), however, exceeded 1E-06. The cancer risks were wholly the result of potential exposure to contaminants in groundwater (arsenic, bis(2-ethylhexyl)phthalate). As discussed in Section 1.5.4, the elevated arsenic in groundwater was likely a sampling artifact (samples contained high amounts of silt) and was not present as a result of KBPOP contamination. Arsenic was not detected in the confirmatory sampling round and is not a COC. Bis(2-ethylhexyl)phthalate is a common laboratory contaminant and is not considered to be a risk driver.

1.6.2.3 Evaluation of Radionuclides

Cancer risks resulting from potential exposure to radionuclides were assessed two ways: (1) a numeric risk comparable to the risk derived for non-radiological carcinogens was derived, and (2) a dose equivalent was derived for direct comparison to EPA criteria (0.1 rem/year).

Radionuclide risk by ingestion, dermal contact, inhalation, and external gamma exposure was calculated in the same manner as chemical intake except that the averaging time and body weight are not taken into account. The derived risk was compared to the EPA target range of 1E-6 to 1E-04. The derived risk for the known on-unit worker was below the EPA target. The derived risks for both the hypothetical on-unit worker and resident, however, exceeded 1E-04. These risks were due primarily to exposure to I-129, Ra-228, H-3, U-233/234 and U-238 in groundwater, and external exposure to Cs-137 in soil. As discussed in Section 1.5.4, the elevated radionuclides in groundwater were likely a sampling artifact (samples contained high amounts of silt) and were not present as a result of KBPOP contamination. I-129, which resulted in 95% of the calculated risk, was not detected in the confirmatory sampling round and is not a COC at this site. When I-129 is excluded from the risk calculation, the risk is 1E-05. Cs-137 in surface soil is likely ubiquitous at the K-Area due to global radioactive fallout and is believed not to be a risk driver.

The dose equivalent was derived to normalize the biological effects produced from equally absorbed doses of different types of radiation. The radiation dose equivalent to specified organs for radionuclides via ingestion, inhalation or external exposure are estimated by multiplying the amount intake times the appropriate dose conversion factors (DCFs), which represent the dose equivalent per unit intake The dose equivalents derived for all three receptors (known on-unit worker and hypothetical on-unit worker and resident), were below the EPA criteria of 0.1 rem/yr.

1.7 ECOLOGICAL EVALUATION

As described in the RI/BRA, the ecological screening step resulted in the conclusion that no chemicals are ecological COCs at the KBPOP. Therefore, no constituents are considered to have the potential to pose adverse effects to the assessment endpoints.

A hierarchy of assessment endpoints was selected in order to assess both proximate and ultimate risks that might be associated with unit-related chemicals. The proximate assessment endpoint was chosen to provide protection of the population levels of vertebrate species that utilize the area of the unit to a significant extent and that are important as indicators of potential effects on the health of the community. Oldfield mice represent terrestrial vertebrate populations at the unit. Potential toxic effects that may reduce this assessment endpoint population or the populations they represent in the immediate vicinity of the unit have not been identified, nor have effects on the ultimate, more important, assessment endpoint: the community of species that occupies the area surrounding and including the unit. It is this ultimate assessment endpoint, maintenance of the health and diversity of the natural community in the area, that is the most important ecological component to be protected with regard to this unit.

The ecological setting of the unit is not characterized by uniqueness or significance. There are no endangered, threatened, or special concern species in the vicinity that are likely to be dependent on or affected by the habitat at the unit. The species that inhabit the unit are not rare in the region, and are not generally considered to be of special societal value. The area of the unit is small and the habitat it provides appears to be relatively low in diversity and productivity.

None of the constituents detected in soil at the KBPOP were concluded to have the potential for adverse effects to the oldfield mouse individuals that may use the unit as a foraging area. It is also unlikely that the constituents would cause a significant adverse effect on the ecological community. Therefore, there are no ecological COCs at the KBPOP.

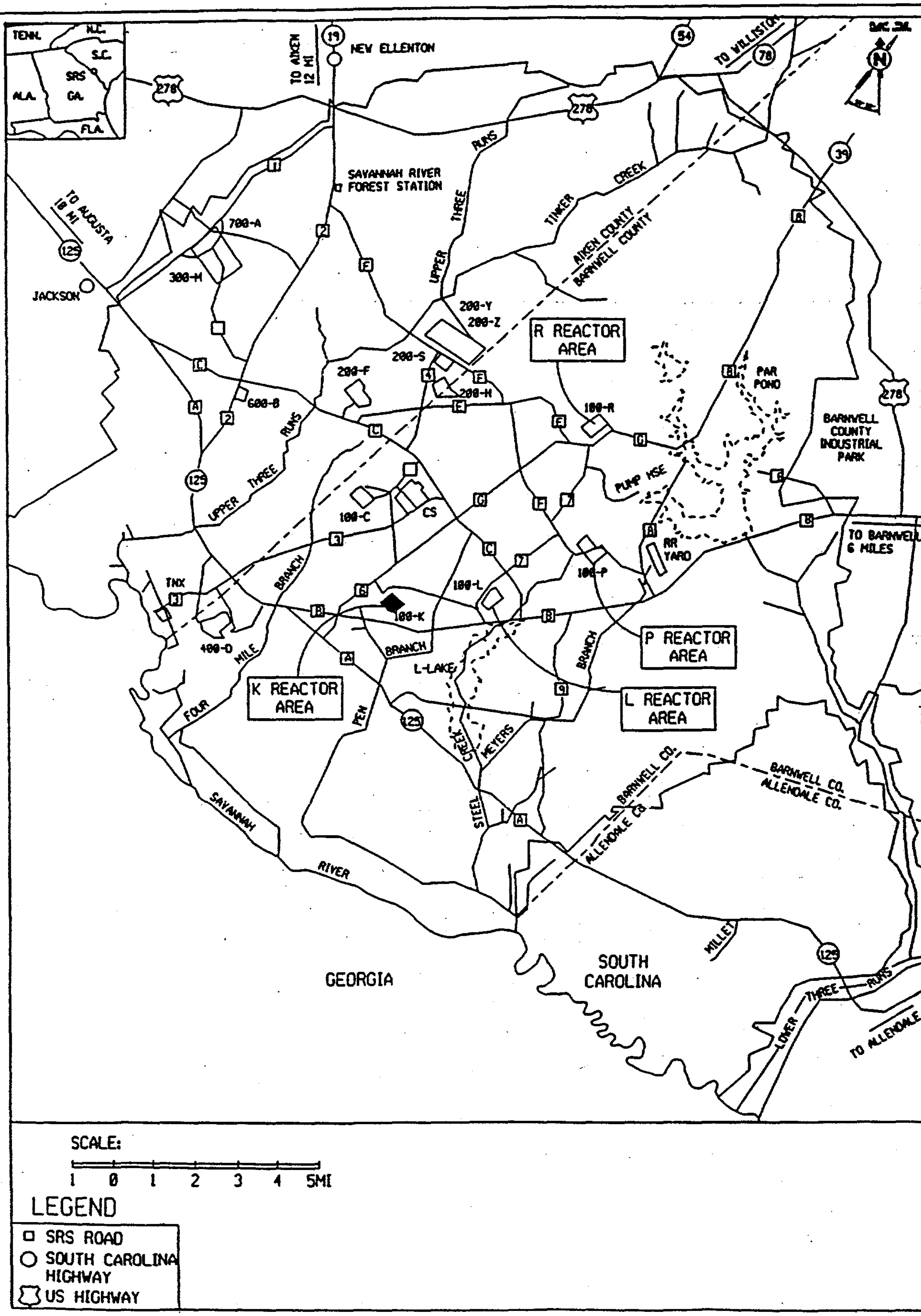

Figure 1.1 Site Location Map -- SRS Reactor Areas

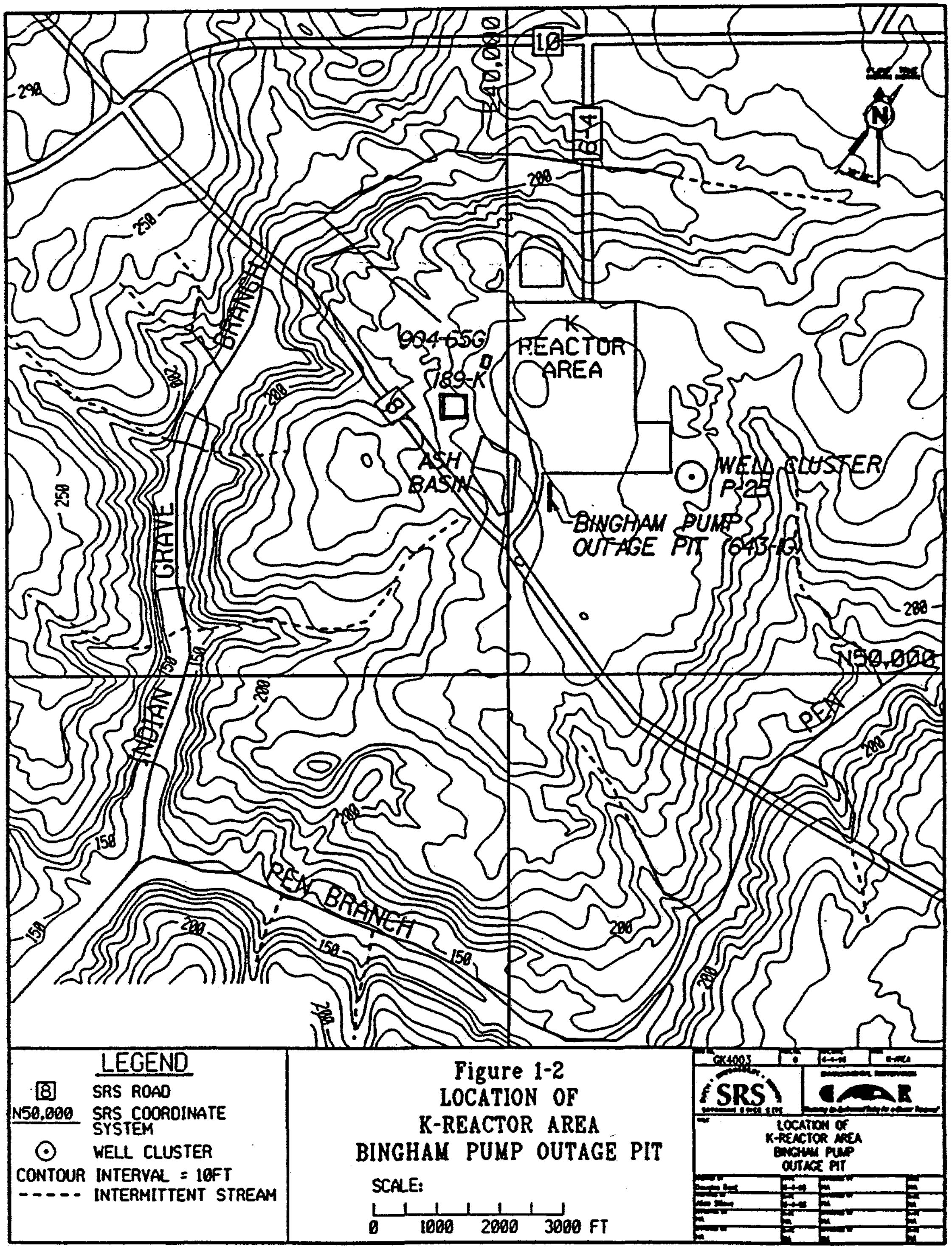

Figure 1.2 Location of K-Reactor Area -- Bingham Pump Outage Pit

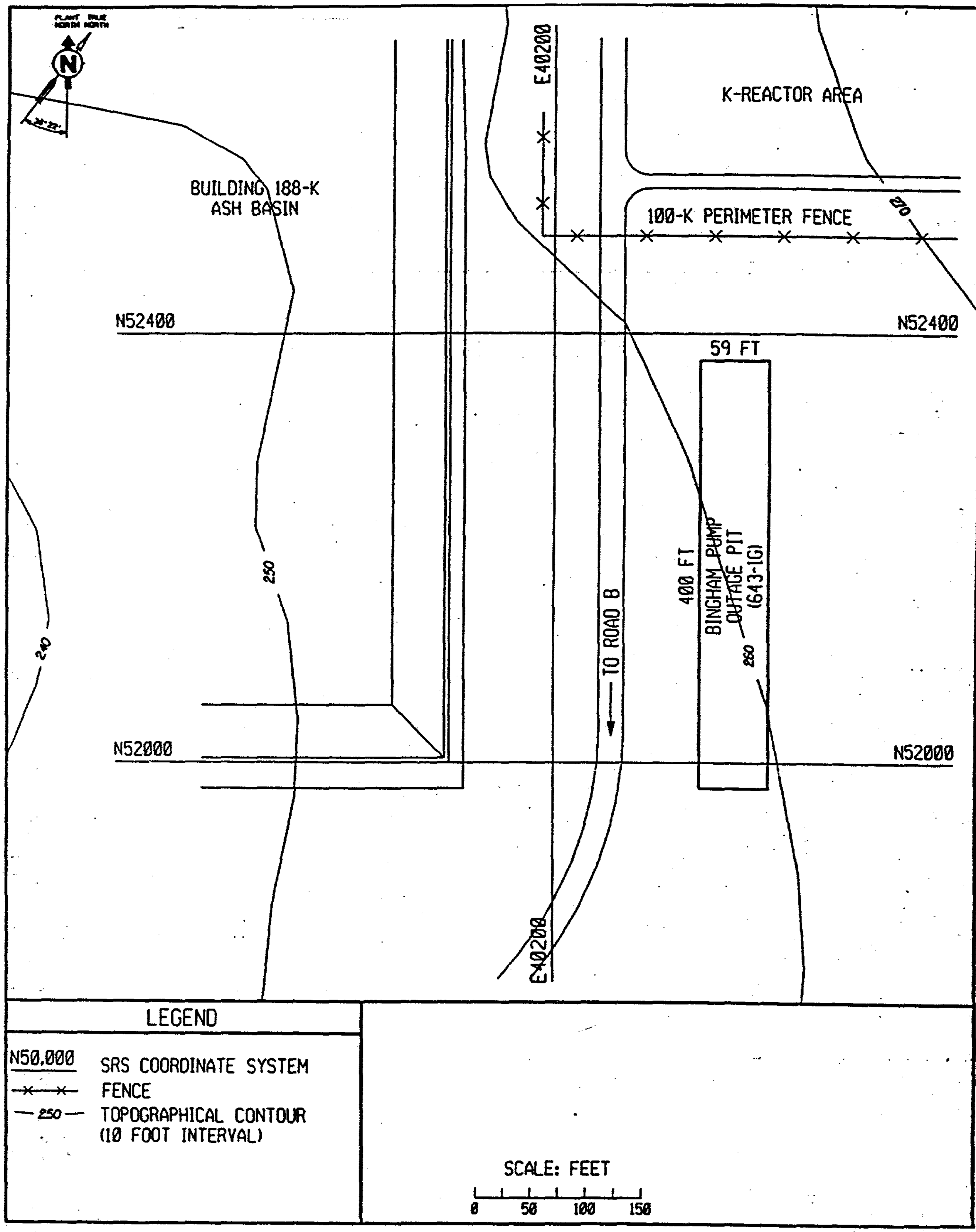

Figure 1.3 Outage Pit Dimensions -- K-Reactor Area

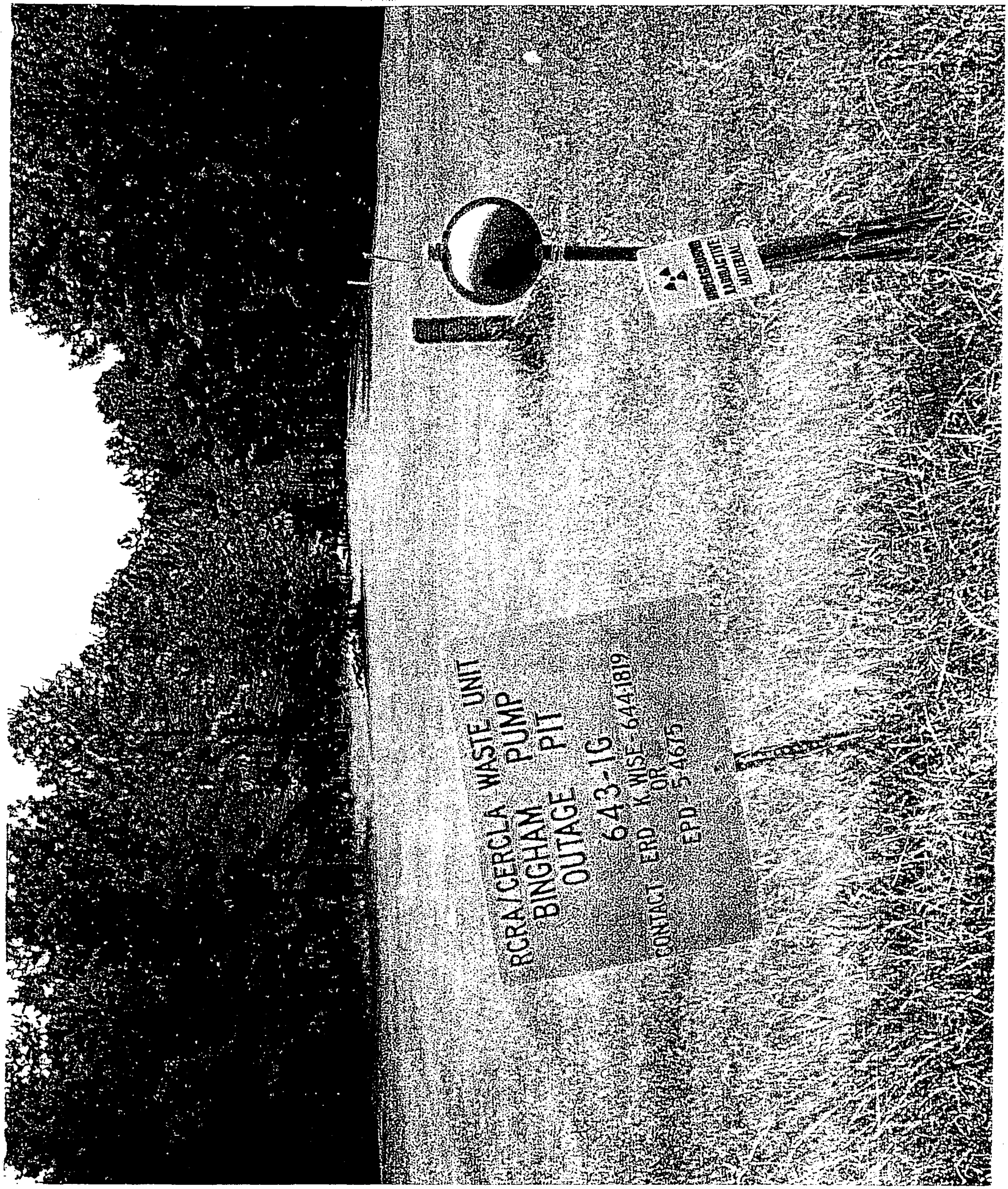

Figure 1.4 Photo of the KBPOP

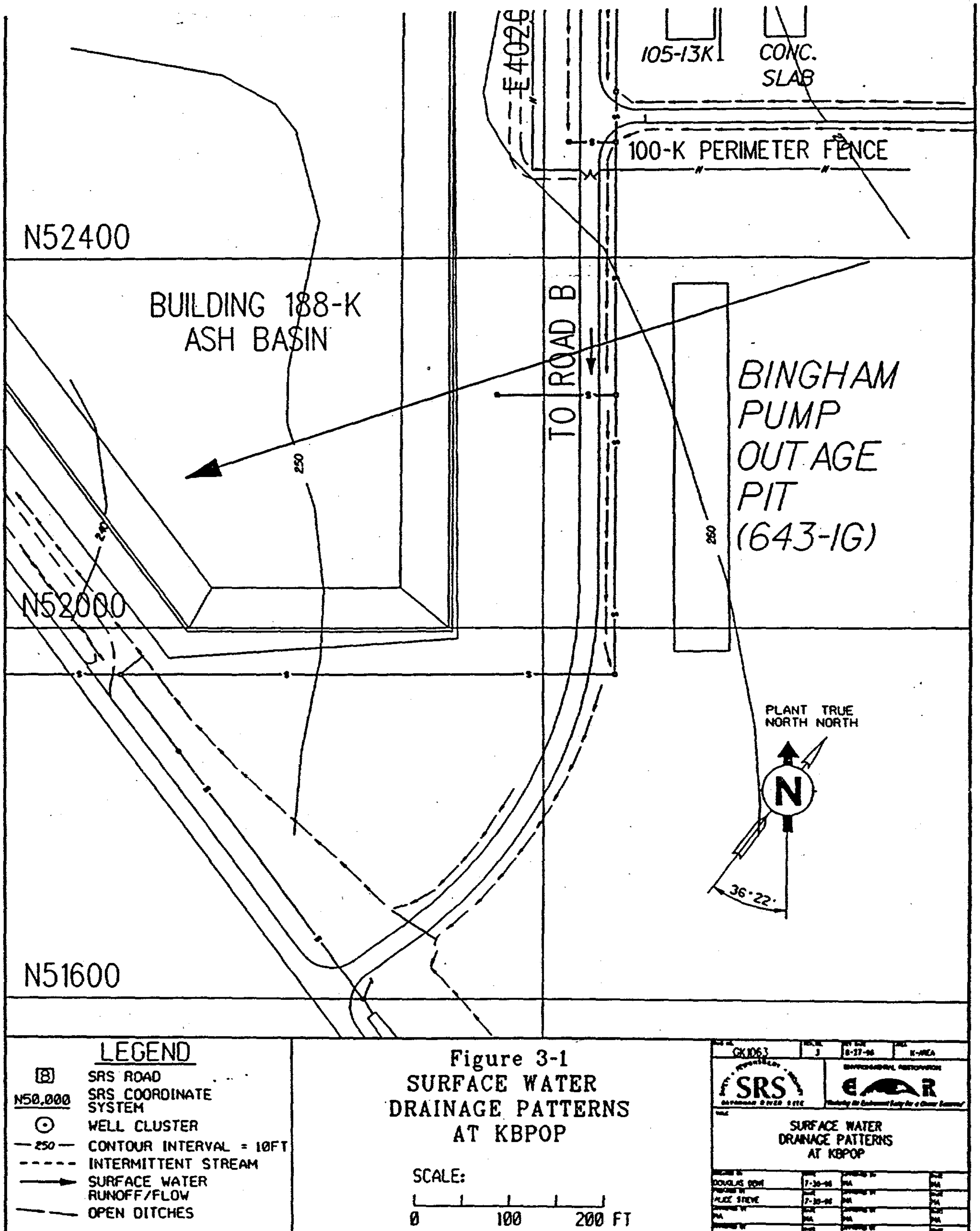

Figure 1. 5 Surface Water Drainage Patterns at KBPOP

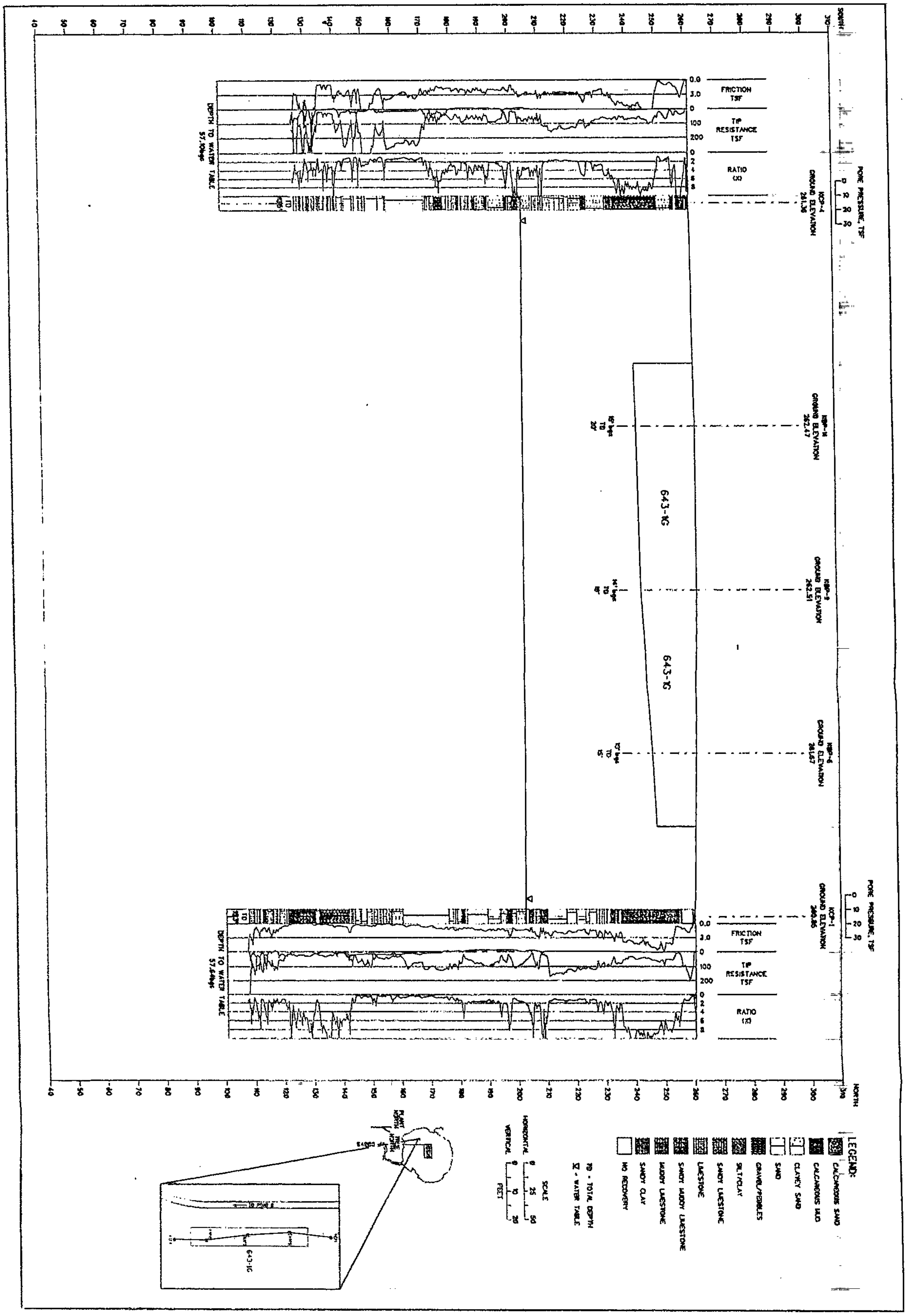

Figure 1.6 North-South Cross-Section at KBPOP

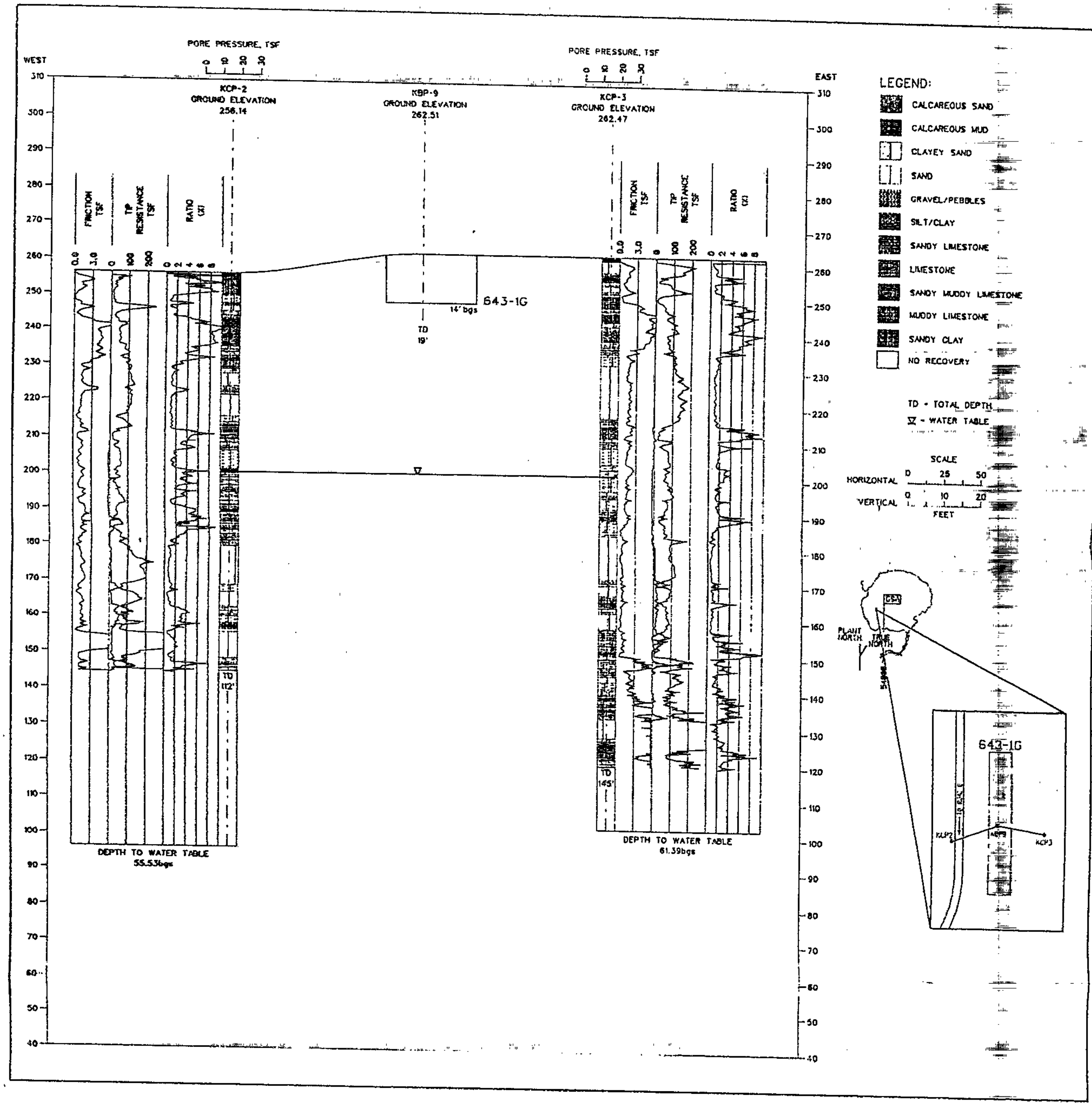

Figure 1.7 East-West Cross-Section at KBPOP

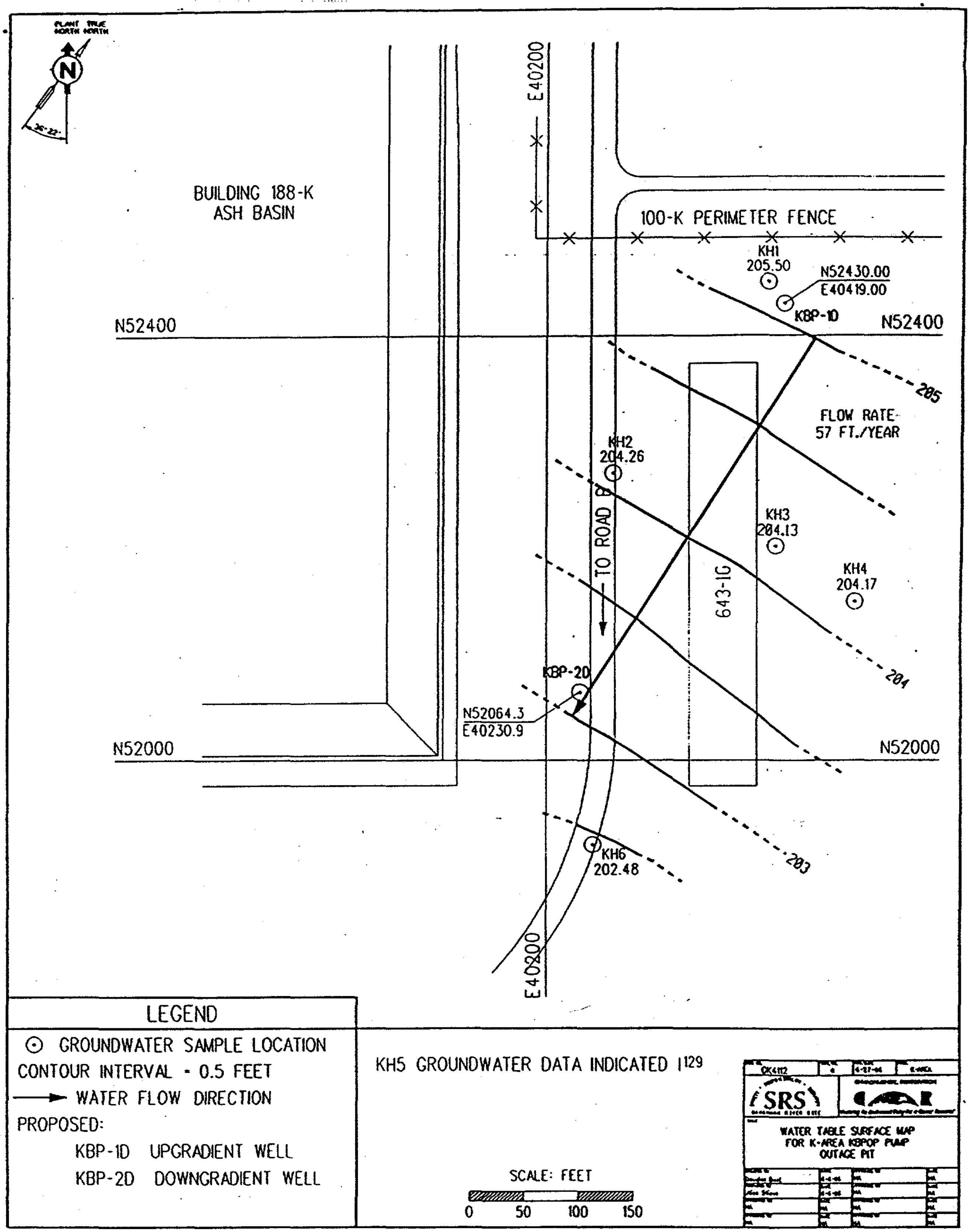

Figure 1.8 Water Table Surface for KBPOP

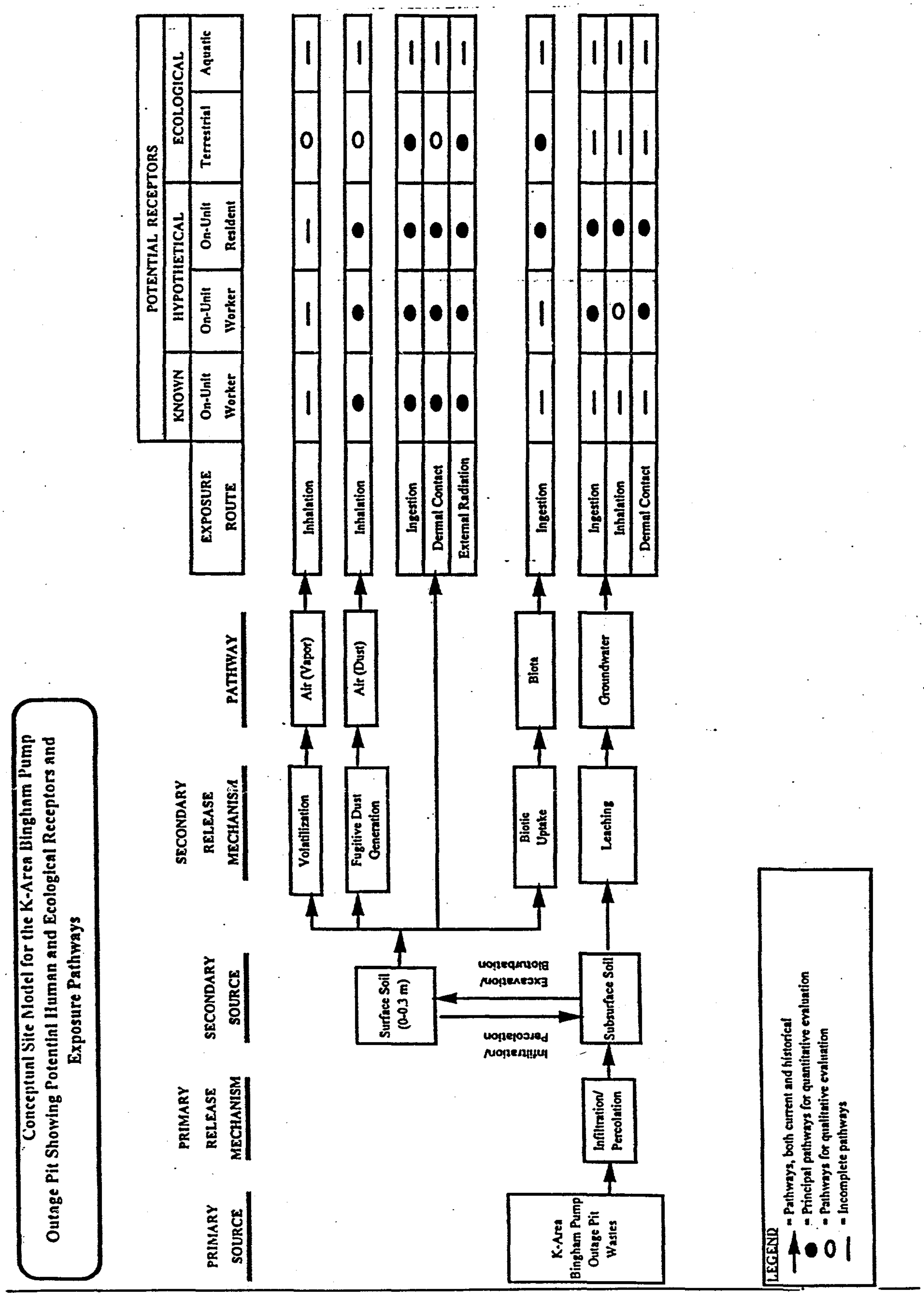

Figure 1.9 Conceptual Site Model for KBPOP

Table 1.1 Estimated Radionuclide Inventory in the Bingham Pump Outage Pits (K-, L-, P-, and R-Reactor Areas)

Radionuclide	Inventory at Burial (Ci)	Inventory Corrected for Decay Through 12/31/95 (Ci)
^{60}Co	0.172	1.34E-03
^{90}Sr	0.112	4.70E-02
$^{103,106}Ru$	0.130	1.12E-12
^{137}Cs	0.414	1.75E-01
^{147}Pm	0.172	7.50E-06
Total	**1.0**	**2.23E-01**

Table 1.2 Characteristics of the Bingham Pump Outage Pits

Area	Pit Identification	Length (ft)	Width (ft)	Depth (ft bgs)	Approximate Waste Volume (ft^3)[a]	Observations
K[b]	643-1G[c]	400	59	Estimated - 13 Actual Minimum - 10 Actual Maximum - 15	212,400	Base of pit sloping Subsidence of surface Low level rad waste
L[b]	643-2G	275	22	Estimated - 13	54,450	Subsidence of surface Low level rad waste
L[b]	643-3G	377	20	Estimated - 13	67,860	Subsidence of surface Low level rad waste
P[b]	643-4G	472	26	Estimated - 13	110,448	Subsidence of surface Low level rad waste
R[b]	643-8G	250	20	Estimated - 13	45,000	Subsidence of surface Low level rad waste
R[b]	643-9G	250	16	Estimated - 13	36,000	Subsidence of surface Low level rad waste
R[b]	643-10G	522	19	Estimated - 13	122,148	Subsidence of surface Low level rad waste

[a] based on an estimated 9 feet of debris
[b] located within a defined Industrial Zone (Figure 1-5)
[c] located within Udorthent soil series

SECTION 2
IDENTIFICATION AND SCREENING OF TECHNOLOGIES

This section identifies remedial action objectives and response actions as well as remedial technologies and associated process options that have been identified as being potentially applicable to the waste and media of concern at the BPOP waste unit group. The process options are evaluated on the basis of potential conditions at any of the BPOPs. Process options representing the applicable technologies are then combined into remedial alternatives to address remediation at the BPOPs. Detailed screening of alternatives for the K-Area BPOP is presented in Section 3.

2.1 INTRODUCTION

The identification and screening of technologies was the initial task in the FS process of identifying remedial action alternatives for the BPOP waste unit group. The screening process began with the development of remedial action objectives (RAOs) and descriptions of general response actions for each media of interest. Potentially applicable treatment technologies (physical treatment, chemical treatment, biological treatment, etc.) were then identified through literature review and professional experience with general site conditions and contaminants of concern.

Technology types, which are general categories of response actions, were expanded to include a variety of process options within the selected technology types. During the selection process, consideration was given to a process option's ability to meet necessary RAOs or waste unit group limitations. The list of potentially applicable process options was then refined by eliminating those process options that were not considered acceptable candidates due to technical implementability limitations and, subsequently, limited effectiveness and/or prohibitive cost.

During the next step of the screening process, the remaining technology types and associated process options were evaluated in greater detail. The process options within each technology type were compared with each other and analyzed in terms of effectiveness, relative cost, and implementability. When possible, a single process option was selected to represent a given technology type. Multiple process options were retained within a technology type when they offered significantly different treatment schemes or were often used in tandem (i.e., air stripping as a primary treatment method followed by carbon adsorption as a polishing step to attain RAOs). The process option(s) representing the treatment technology types were combined into several remedial alternatives.

2.2 REMEDIAL ACTION OBJECTIVES

Remedial action objectives were developed under the following considerations: Media and contaminants of concern; potential exposure pathways; and media-specific remediation goals that are intended to protect human and environmental receptors from exposure to harmful levels of contaminants. Remedial action objectives were set for groundwater and for soil for contaminants detected at levels representing potential risks to human health.

At this stage, general RAOs were developed for the BPOP waste unit group. Specific RAOs for the KBPOP are developed in Section 3, where remedial alternatives are screened to select those that are applicable to K-Area. Combining the contaminants and media of concern, the exposure pathways and receptors and the target goals for the contaminants of concern, the following general RAOs are defined.

- Remedial Action Goal for Soil
  - To prevent human exposure, via any exposure route (ingestion, inhalation, or dermal contact) to soil containing contaminants in concentrations that exceed appropriate risk levels.
  - To prevent environmental exposure to soil containing contaminants in concentrations that are likely to negatively stress environmental receptors
  - To prevent migration of contaminants from the soil into other media (groundwater or surface water) at concentrations that would fail to meet the RAOs for that media.
- Remedial Action Goal for Groundwater
  - To prevent human exposure, via any exposure route (ingestion, inhalation, or dermal contact) to groundwater containing contaminants in concentrations that exceed applicable or relevant and appropriate requirements (ARARs) or appropriate risk levels.
  - To prevent migration of groundwater into other media (surface water) at concentrations that would fail to meet concentration limits for that media.

2.3 GENERAL RESPONSE ACTIONS

General response actions are those actions that will address the RAOs. The general response actions for the BPOP waste unit group address soil contamination and groundwater contamination. The general response actions for soil, identified in Table 2.1, are:

- No remedial action;

- Institutional controls;
- Containment;
- In-situ treatment;
- Ex-situ treatment; and
- Disposal.

The general response actions for groundwater, identified in Table 2.2, are:

- No remedial action;
- Institutional controls;
- Containment;
- Recovery;
- Treatment; and
- Disposal.

2.4 IDENTIFICATION AND SCREENING OF TECHNOLOGY TYPES AND PROCESS OPTIONS

Technology types and process options for each general response action were evaluated for their applicability under the site-specific conditions. The results of this evaluation are shown in Tables 2.1 and 2.2.

The technology types and process options found to be potentially applicable under the site-specific conditions were evaluated against one another in terms of effectiveness, relative cost, and implementability. Tables 2.3 and 2.4 present the results of this initial screening of technology types and process options. These tables also present the rationale for selection of technology types and process options retained for alternative analysis.

2.4.1 Soil Technology Types and Process Options

Table 2.3 identifies the process options retained for alternative development.

2.4.1.1 No Remedial Action

The no remedial action option is retained for further evaluation. It provides a baseline against which other technology types and process options can be evaluated. Under the no remedial action option, soil conditions would vary only as a result of natural processes. Such processes include natural biodegradation by indigenous microorganisms, chemical degradation (changes in sorption due to variations in contaminant concentrations in groundwater), or changes in the soil's sorption potential. Erosion of surface soil could possibly expose contaminated soil and increase rates of leaching or runoff of contaminants, and no controls would exist to prevent future development of the site.

2.4.1.2 Institutional Controls

If exposure to surface contamination is a potential threat at a BPOP, access restrictions, such as fencing, could reduce the threat of unauthorized entry. This would reduce the risk of contact with surface contamination. Deed restrictions/notifications could be used to prevent future development on the BPOPs if DOE relinquishes ownership of SRS. Security controls were eliminated from considerations because they are only marginally more effective than other access restrictions, such as fencing, but have greater long-term maintenance requirements.

2.4.1.3 Containment

Several containment strategies were considered for implementation at the BPOPs, including soil covers; RCRA, composite, asphalt, and capillary barrier caps; and soil vegetation.

Single-layer caps (soil covers) will be further evaluated as a means of preventing human contact with contaminated soil, reducing the potential for future infiltration of stormwater, and preventing erosion. Maintenance of the existing soil vegetative cover was also eliminated as an option. Asphalt caps were eliminated because the site is not likely to receive future industrial uses. RCRA, composite, and capillary barrier caps were eliminated because their costs are at least 50 percent greater, but they do not provide significantly greater reductions in threats.

2.4.1.4 In-Situ Treatment

Electrokinetic soil processing was eliminated from further consideration because it is an unproven technology that may not be effective for the COCs at the BPOPs. Bioremediation was eliminated due to the unlikeliness that it would result in attainment of cleanup goals for all COCs. All other in-situ treatment techniques were eliminated due to the high volume of debris buried in the BPOPs. Potential problems include incomplete treatment of contaminated material and the high volume of metallic material in the debris.

2.4.1.5 Ex-Situ Treatment

Several stabilization/solidification processes were evaluated for ex-situ treatment. Cement-based treatment was judged to be potentially effective for treatment of the COC at KBPOP. Pozzolonic, thermoplastic, macroencapsulation, and microencapsulation processes were eliminated because the costs are greater than for cement-based treatment, but the effectiveness is essentially the same.

Chemical extraction and soil washing were eliminated because it was judged to be ineffective for the types of contaminants commonly found at BPOPs.

2.4.1.6 Disposal

On-site disposal in E-Area vaults was retained as a potential disposal option for excavated soil, either before or after treatment is conducted. The Soil Consolidation Facility was also retained, although the facility is currently in the preconceptual stage and may not be on-line when remediation is conducted. Mixed waste storage buildings were also considered, but eliminated due to the limited lifetimes of the buildings.

Off-site disposal at Envirocare was retained as a potential off-site disposal option, although treatment may be required prior to waste disposal. Disposal at the Nevada Test Site was eliminated due to high transportation costs, which are not warranted for low-level contamination typical of the BPOPs.

2.4.2 Groundwater Technology Types and Process Options

Table 2.4 identifies the process options retained for alternative development.

2.4.2.1 No Remedial Action

The no remedial action or natural attenuation/degradation option has been retained for further consideration. This option provides a baseline against which all other options may be evaluated.

2.4.2.2 Institutional Controls

Institutional controls such as an alternate water supply, alternate concentration limits (ACLs), and periodic groundwater monitoring were all retained as potentially implementable individually or in tandem with treatment options.

Alternate water supplies would be effective if residential, industrial, or agricultural water supplies become contaminated. However, since water supply wells are not contaminated, the alternate water supply alternative was eliminated. The use of ACLs may be appropriate if ARARs are exceeded but there are no human health threats from groundwater; however, the use of ACLs must be approved by the South Carolina Department of Health and Environmental Control. Long-term monitoring will allow an assessment of changes in groundwater contaminant conditions and could be used with any other alternative.

2.4.2.3 Groundwater Containment

Soil covering and slurry walls were retained as potentially effective options for reducing contaminant migration. Sheet piles and grout curtains were eliminated because they all offer less effectiveness than either capping or slurry walls.

2.4.2.4 Groundwater Recovery

The extraction well process option was retained for collection and removal of groundwater as readily implementable at the site. Interceptor trenches were considered to be technically impractical due to depth requirements at the BPOPs. Hydraulic fracturing, for increasing the rate of recover, was eliminated based on soil conditions.

2.4.2.5 Treatment

Physical Treatment

Activated carbon adsorption was retained for treatment of organic contaminants, but the use of other treatment methods may be necessary for inorganic contaminants. Air stripping, air sparging, and UV oxidation were eliminated because they are used primarily for the treatment of volatiles, which are not a primary concern at the BPOPs. In-situ steam stripping was eliminated because clay layers could prevent complete treatment. Reverse osmosis, polishing filters, and membrane microfiltration were eliminated because other treatment methods would be more cost-effective.

Chemical Treatment

Ion exchange, clarification/filtration, chemical oxidation/reduction, reverse osmosis and metals precipitation were all retained as potentially-effective treatment options. The specific treatment method will be dependent upon the types and concentrations of contaminants present at the individual BPOPs.

Point of Use Treatment

Point-of-use treatment was eliminated as a process option for treating because residential wells are not currently, and are not anticipated to become, contaminated from the BPOPs.

Biological Treatment

Biological treatment process options were not retained because they are unlikely to result in attainment of cleanup goals.

2.4.2.6 Disposal

Onsite disposal, by reinjection and by spray irrigation, were retained as potentially effective methods for disposal of groundwater following treatment. Off-site disposal in a publicly-owned treatment works (POTW) was also retained as an option for disposing of either treated or untreated groundwater.

Table 2.1. Screening Summary for Soil Remedial Technologies for the Bingham Pump Outage Pits Waste Group[1], Savannah River Site, South Carolina

General Response Actions	Technologies & Process Options	Screening Status	Screening Comments
No Remedial Action	No remedial action	retained	Consideration required under NCP.
Institutional Controls	Access Control		
	access restrictions/fencing	retained	Potentially effective for reducing threat of direct contact with contaminated material; may be used in conjuction with other response actions.
	deed restrictions	retained	Same as above.
	security controls	eliminated	High long-term maintenance; only marginally more effective than access restictions/fencing.
Containment	Soil Covering		
	single-layer soil cover	retained	Potentially effective for reducing contaminant leaching and reducing threat of direct contact.
	RCRA soil cover	eliminated	Leaching from soil is only a marginal threat; much greater additional cost would not provide significant reduction in potential threat.
	composite soil cover	eliminated	Same as above.
	asphalt soil cover	eliminated	Greater maintenance costs than single-layer soil cover without providing significantly greater benefits.
	capillary barrier soil cover	eliminated	Same as RCRA and composite soil covers.
	Soil vegetation	eliminated	May not provide adequate drainage or homogenous soil cover characteristics.

Table 2.1 (continued). Screening Summary for Soil Remedial Technologies for the Bingham Pump Outage Pits Waste Group, Savannah River Site, South Carolina

General Response Actions	Technologies & Process Options	Screening Status	Screening Comments
In-Situ Treatment	Stabilization/solidification		
	cement	retained	Potentially effective for reducing contaminant migration from soil to groundwater.
	pozzolanic process	eliminated	Cement-based process would provide similar protection at lower cost.
	thermoplastic	eliminated	Same as above.
	Electrokinetic soil processing	eliminated	Not a proven technology; may not be effective for the contaminants of concern
	Vitrification	retained	Potentially effective for reducing contaminant migration from soil to groundwater.
	Solvent flushing	eliminated	Debris buried in soil would likely reduce solvent contact with soil, resulting in areas left untreated.
	In-situ bioremediation	eliminated	Primarily used for organic contaminants; unlikely to meet cleanup goals for contaminants of concern
Ex-Situ Treatment	Stabilization/solidification		
	cement	retained	Potentially effective for reducing contaminant migration from soil to groundwater.
	pozzolanic process	eliminated	Cement-based process would provide similar protection as lower cost.

Table 2.1 (continued). Screening Summary for Soil Remedial Technologies for the Bingham Pump Outage Pits Waste Group, Savannah River Site, South Carolina

General Response Actions	Technologies & Process Options	Screening Status	Screening Comments
	thermoplastic	eliminated	Same as above.
	macroencapsulation	eliminated	Same as above.
	microencapsulation	eliminated	Same as above.
Ex-Situ Treatment (continued)	Chemical extraction	eliminated	Not effective for types of contaminants commonly found at BPOPs.
	Soil washing	eliminated	Not effective for types of contaminants commonly found at BPOPs.
Disposal	SRS disposal		
	E-Area Vaults	retained	Feasible option for disposal of excavated soil, either before or after treatment
	Mixed Waste Storage Buildings	eliminated	Not feasible for permanent storage due to limited lifetime of buildings and access control problems.
	Soil Consolidation Facility	retained	Facility is in preconceptual stage and may not be online during remediation. Retained as innovative technology pending facility development.
	Off-site disposal		
	Nevada Test Site	eliminated	High transportation costs are not warranted for the low-level contamination found at BPOPs.

Table 2.1 (continued). Screening Summary for Soil Remedial Technologies for the Bingham Pump Outage Pits Waste Group, Savannah River Site, South Carolina

General Response Actions	Technologies & Process Options	Screening Status	Screening Comments
	Envirocare	retained	Effective for permanent disposal of excavated waste; treatment may be required prior to disposal.

NOTES

[1]These technologies are potentially applicable for any BPOP in the Waste Group and have not been selected on the basis of conditions at K-Area alone.

Table 2.2. Screening Summary for Groundwater Remedial Technologies for the Bingham Pump Outage Pits Waste Group[1], Savannah River Site, South Carolina

General Response Action	Technologies & Process Options	Screening Status	Screening Comments
No Remedial Action	No remedial action	retained	Consideration required under NCP.
Institutional Controls	Alternate water supply	eliminated	Water supply wells are not contaminated.
	Access controls	retained	Potentially effective for restricting use of groundwater in contaminated areas.
	ACL/MZCL	retained	Potentially effective if ARARs are exceeded, but no significant health risk is posed.
	Groundwater monitoring	retained	Effective for determining contaminant degradation, attenuation, migration.
Containment	Soil covering	retained	Potentially effective for reducing infiltration and reducing contaminant leaching and migration from source area.
	Vertical barriers		
	slurry walls	retained	Potentially effective for reducing contaminant migration from source area.
	sheet piles	eliminated	Slurry walls offer greater reliability.
	grout curtains	eliminated	Same as above.
	Horizontal grout curtain	eliminated	Buried debris may hinder placement of curtain and reduce effectiveness.

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Table 2.2 (continued). Screening Summary for Groundwater Remedial Technologies for the Bingham Pump Outage Pits Waste Group[1], Savannah River Site, South Carolina

General Response Action	Technologies & Process Options	Screening Status	Screening Comments
Groundwater Recovery	Extraction wells	retained	Potentially effective for recovering contaminated groundwater and for reducing contaminant migration by forming a hydraulic barrier.
	Interceptor trenches	eliminated	Not feasible for the groundwater depths (>50') observed at SRS.
	Hydraulic fracturing	eliminated	Primarily used in consolidated formations, not in unconsolidated sediments typical of SRS.
Treatment			
Physical Treatment	Activated carbon adsorption	retained	Potentially effective for removing organic contaminants; may be necessary to use in conjuction with other treatment methods.
	Air stripping	eliminated	Primarily used for volatile organics; relatively ineffective for contaminants at this site.
	Air sparging	eliminated	Same as above.
	UV oxidation	eliminated	Same as above.
	Steam stripping (in-situ)	eliminated	May be ineffective due to clay layers; treatment for inorganics would still require groundwater recovery, so ex-situ treatment for organics would be more cost-effective.
	Reverse osmosis	retained	Potentially effective for removing contaminants.

Table 2.2 (continued). Screening Summary for Groundwater Remedial Technologies for the Bingham Pump Outage Pits Waste Group[1], Savannah River Site, South Carolina

General Response Action	Technologies & Process Options	Screening Status	Screening Comments
Physical Treatment (continued)	Heavy metals/radionuclide polishing filter	eliminated	Same as above.
	Membrane microfiltration	eliminated	Same as above.
Chemical Treatment	Ion exchange	retained	Potentially effective for removing contaminants of concern; may be necessary to use in conjuction with other treatment methods.
	Chemical oxidation/ reduction	retained	Same as above.
	Clarification/ filtration	retained	Same as above.
	Metals precipitation	retained	Same as above.
Point of Use Treatment	In home treatment units	eliminated	Residential wells are not currently or projected to be impacted by groundwater contamination.
Biological Treatment	In situ bioremediation	eliminated	Unlikely to meet cleanup goals for the contaminants of concern; treatment may be difficult due to high clay content in aquifer.
	Bioreactors	eliminated	Unlikely to meet cleanup goals for the contaminants of concern.

Table 2.2 (continued). Screening Summary for Groundwater Remedial Technologies for the Bingham Pump Outage Pits Waste Group[1], Savannah River Site, South Carolina

General Response Action	Technologies & Process Options	Screening Status	Screening Comments
Disposal	SRS disposal		
	reinjection	retained	Effective for disposal of recovered groundwater following treatement.
	spray irrigation	retained	Same as above.
	Off-site disposal		
	POTW	retained	Effective for disposal of recovered groundwater; pretreatment may or may not be required.

[1]These technologies are potentially applicable for any BPOP in the Waste Group and have not been selected on the basis of conditions at K-Area alone.

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Table 2.3. Retained Soil Remedial Technologies for the Bingham Pump Outage Pits Waste Group[1], Savannah River Site, South Carolina

General Response Action	Potential Technology
No Remedial Action	No remedial action
Institutional Controls	Access Control Access Restriction/ Fencing Deed Restrictions/Notifications
Containment	Soil Covering Single layer soil cover
Treatment	
Ex-Situ Treatment	Stabilization/solidification (cement)
In-Situ Treatment	Stabilization/solidification (cement) Vitrification
Disposal	SRS disposal Soil Consolidation Facility E-Area vaults Off-site disposal Envirocare

[1]These technologies are potentially applicable for any BPOP in the Waste Group and have not been selected on the basis of conditions at K-Area alone.

Table 2.4. Retained Groundwater Remedial Technologies for the Bingham Pump Outage Pits Waste Group[1], Savannah River Site, South Carolina

General Response Actions	Potential Technologies & Process Option
No Remedial Action	No remedial action
Institutional Controls	ACL/MZCL Groundwater monitoring Access Controls
Containment	Soil Covering Vertical barriers slurry walls
Groundwater Recovery	Extraction wells
Treatment	
Physical Treatment	Activated carbon adsorption
Chemical Treatment	Ion exchange Chemical oxidation/reduction Clarification/filtration Metals precipitation Reverse osmosis
Disposal	SRS disposal reinjection spray irrigation Off-site disposal POTW

[1]These technologies are potentially applicable for any BPOP in the Waste Group and have not been selected on the basis of conditions at K-Area alone.

SECTION 3
DEVELOPMENT OF ALTERNATIVES

In this section, remedial technologies are grouped into ranges of remedial alternatives for soil and for groundwater. The criteria used for the evaluation of the alternatives are also presented.

3.1 SITE-SPECIFIC REMEDIAL ACTION OBJECTIVE

General RAOs for the BPOP waste unit group were developed in Section 2. Remedial goal options specific to the KBPOP were developed in the RI/BRA. These RGOs are:

	Target Cancer Risk		
Receptor	**1.00E-04**	**1.00E-05**	**1.00E-06**
Future Worker (pCi/g)	1.06E+01	1.06E+00	1.06E-01
Future Resident (pCi/g)	2.08E+00	2.08E-01	2.08E-02

The development of the RGOs is discussed in further detail in Section 4.

3.2 SELECTION OF REMEDIAL ALTERNATIVES

Alternatives were developed by combining technology types into candidate remedial action alternatives. The technology types remaining from the screening in Section 2 are potentially applicable at any of the BPOPs. Those technology types that are applicable to KBPOP were used for the development of these KBPOP-specific alternatives. Therefore, technology types identified in Section 2 may not all be carried forward into this section.

Alternatives were developed for each media based on the results of the technology screening. The alternatives represent a range of remedial options to achieve the RAOs. The alternatives could be combined if necessary so that different technologies complement each other to effect achievement of the RAOs.

The following preliminary remedial alternatives were developed for soil and debris:

Alternative 1: No Remedial Action

Rationale: *The No Remedial Action alternative is required by the NCP.*

Alternative 2: Access and deed restrictions/notifications

Rationale: *Access restrictions and deed restrictions/notifications meet the general response of institutional controls. Potential current and future exposure pathways are eliminated or reduced by site control mechanisms.*

Alternative 3: Soil cover

Rationale: *Placing a soil cover over the waste disposal area satisfies the general response of containment. While Alternative 3 minimizes waste handling, it offers no reduction in waste toxicity or volume. A soil cover does offer potential reductions in contaminant mobility into groundwater.*

Alternative 4: Excavate debris and dispose at E-Area Vaults or Soil Consolidation Facility; backfill; soil cover

Rationale: *Alternative 4 satisfies the general response of containment. This alternative provides additional protection through removal of debris. The tradeoff is additional waste handling.*

Alternative 5: Excavate debris and dispose at Envirocare Facility; backfill; soil cover

Rationale: *Alternative 5 satisfies the general response of containment. This alternative provides additional protection through removal of debris from SRS property. The tradeoff is additional waste handling and cost.*

Alternative 6: In-situ solidification of soil and debris; soil cover

Rationale: *Alternative 6 addresses the general response of in-situ treatment. This alternative focuses on treating the most accessible and contaminated soil so as to minimize waste handling.*

Alternative 7: Excavate debris and dispose off-unit; in-situ solidification/ stabilization of soil; backfill; soil cover

Rationale: *Alternative 7 satisfies the general response of in-situ treatment. This alternative provides additional protection through removal of debris. The tradeoff is additional waste handling.*

Alternative 8: Excavate debris and dispose off-unit; in-situ vitrification of soil; soil cover

Rationale: *Alternative 8 involves an innovative technology that addresses the general response of in-situ treatment. Alternative 7 focuses on* *treating all known contaminated soil. Vitrification offers the potential for superior long-term effectiveness over grouting. The tradeoff is greater cost.*

Alternative 9: Excavate debris and dispose off-unit; excavate soil; solidify/stabilize soil; backfill treated soil; soil cover.

Rationale: *Alternative 9 addresses the general responses of ex-situ treatment and containment. This alternative focuses on treating the contaminated soil. This alternative requires more waste handling, but offers confirmation that treatment of contaminated media achieves a minimum treatment standard.*

Alternative 10: Excavate debris and dispose off-unit; excavate soil; vitrify soil; backfill treated soil; soil cover.

Rationale: *Alternative 10 involves an innovative technology that addresses the general response of ex-situ treatment. Alternative 9 focuses on treating the contaminated soil. In addition to confirming that all soil exceeding minimum treatment standards has been treated, vitrification offers the potential for superior long-term effectiveness over grouting. However, ex-situ vitrification will require more waste handling than in-situ treatment and has a significantly greater cost relative to grouting.*

Alternative 11: Excavate soil and debris; solidify/stabilize soil; backfill treated soil and debris; soil cover.

Rationale: *This alternative addresses the general response of ex-situ treatment. Under this alternative, all contaminated material is treated and retained at the site.*

Alternative 12: Excavate debris and soil, disposal in E-Area vaults or Soil Consolidation Facility, if applicable.

Rationale: *Alternative 12 involves the disposal of contaminated soil in a conceptual Soil Consolidation Facility and addresses the general response of off-unit disposal. While this alternative offers complete containment of the waste, off-unit disposal does not offer waste treatment that would reduce the toxicity, mobility, or volume of the waste and would involve waste handling.*

Alternative 13: Excavate debris and soil, off-site disposal at Envirocare facility.

Rationale: *Alternative 13 involves the landfilling of contaminated soil and addresses the general response of off-unit disposal. While this alternative offers containment of the waste, it does not offer waste* *treatment that would reduce the toxicity, mobility or volume of the waste, or otherwise decrease the inherent threats or risks associated with the waste. This alternative would also involve significant waste handling.*

The following preliminary alternatives were developed for groundwater

Alternative 1: No remedial action

Rationale: *The No Remedial Action alternative is required by the NCP.*

Alternative 2: Long-term monitoring

Rationale: *This alternative would provide monitoring of site conditions, which would warn of any changes in groundwater concentration levels.*

Alternative 3: ACL mixing zone

Rationale: *This alternative would consider alternative concentration limits based on potential groundwater uses.*

Alternative 4: Access control

Rationale: *Access restrictions meet the general response of institutional controls. Potential current and future exposure pathways are eliminated or reduced by site control mechanisms.*

Alternative 5: Soil cover

Rationale: *Soil covering would control groundwater contamination by reducing surface water infiltration, leaching of contaminants, and contaminant migration to groundwater.*

Alternative 6: Soil cover and slurry wall

Rationale: *Alternative 6 addresses the general response of containment. The soil cover would reduce infiltration, while the slurry wall would reduce or eliminate the off-site mobility of contaminants.*

Alternative 7: Groundwater recovery; treatment by reverse osmosis

Rationale: *Alternative 7 meets the general response of treatment. Groundwater would be removed by extraction wells or similar methods and treated by reverse osmosis.*

Alternative 8: Groundwater recovery; treatment by ion exchange

Rationale: *Alternative 8 meets the general response of treatment. Groundwater would be removed by extraction wells or similar methods and treated by ion exchange.*

Alternative 9: Groundwater recovery; treatment by precipitation

Rationale: *Alternative 9 meets the general response of treatment. Groundwater would be removed by extraction wells or similar methods and treated by precipitation.*

The conditions of groundwater at the K-Area BPOP are believed to be caused by contamination from other areas. The groundwater at this area will be addressed as part of the treatment plan for the source location. Therefore, only the No Remedial Action alternative was investigated further for the groundwater media.

3.3 SCREENING OF REMEDIAL ALTERNATIVES

3.3.1 Introduction

In accordance with the NCP, it is desirable, when practicable, to offer a range of diverse soil remedial alternatives to select from during detailed analysis. In order to provide a range of potential alternatives for detailed analysis, at least one alternative will be retained that represents each of the following general response actions:

- No remedial action;
- Institutional controls;
- Containment;
- In-situ treatment;
- Ex-situ treatment; and
- Off-unit disposal.

Some alternatives are comprised of two or more general response actions (e.g., in-situ treatment and containment). In such cases, the alternative will be classified as a function of the primary general response action or component of the alternative that enhances its effectiveness over similar alternatives. For example, an alternative that involves in-situ grouting of soil and construction of a soil cover will fall under the general response of in-situ treatment, since in-situ grouting will enhance the alternative's effectiveness over an alternative that involves only a soil cover. The soil cover-only alternative would fall under the general response of containment.

At the alternatives screening point in the FS process, alternatives will be evaluated more generally than during the detailed analysis; however, screening evaluations will be sufficiently detailed to distinguish among similar types of alternatives. Comparisons will be made among alternatives having a common general response action. To ensure that a range of approaches are considered, at least one (i.e., the most promising) alternative from each general response action will be retained for detailed analysis. During comparative analysis (Section 4), comparisons among alternatives will differentiate across the entire range of alternatives.

EPA's CERCLA guidance for the FS process provides three broad criteria against which whole alternatives are evaluated during the screening process (EPA, 1988a). The criteria are:

- Effectiveness;
- Implementability; and
- Cost.

For an alternative to be effective, it must be protective of public health and the environment. Alternatives that do not provide adequate protection of the environment, public health, and public welfare, or do so to a much lesser extent than a comparable alternative, will be rejected and will not be considered for detailed analysis.

Implementability addresses both the technical and institutional feasibility of constructing, operating, and maintaining components of an alternative. Under this criterion, alternatives are evaluated based on the technical feasibility to construct, reliably operate, and meet technology-specific regulations for process options until a remedial action is completed. Alternatives that involve innovative technologies are retained as long as there is "reasonable belief" that the alternative will offer better treatment performance, fewer adverse impacts, or lower costs for similar levels of performance, over alternatives that involve conventional technologies. Alternatives that are clearly less technically or administratively feasible than comparable alternatives may be removed from further consideration.

A quantitative cost evaluation is provided so that cost comparisons can be made among similar types of alternatives. The costs for alternatives are developed for comparison purposes only and are not intended to forecast a budgetary estimate of actual expenditures. Those alternatives that demonstrate comparable levels of effectiveness and implementability as other alternatives but at significantly greater cost will be eliminated. Similarly, alternatives that are equivalent in cost but are clearly less effective than other comparable alternatives will also be rejected. Costs will not be otherwise used as a criterion to screen alternatives at this point in the FS process.

The following subsections present a description of potential alternatives and an evaluation of each alternative based on the screening criteria discussed above. Alternatives retained after this screening will undergo detailed analysis of alternatives in Section 4.

3.3.2 Areas and Volumes of Media

The disposal area at the KBPOP covers an area of approximately 64 feet by 405 feet. This is approximately 26,000 square feet. The total volume of media and debris that would be addressed by the alternatives in this section is approximately 13,150 cubic yards.

3.3.3 Alternatives Under the General Response of No Action

Listed below are a description, screening comments, and evaluation of Alternative 1. Alternative 1 is the only alternative that is categorized under the general response of No Action.

3.3.3.1 Alternative 1: No Remedial Action

Alternative 1 is a true "no action" alternative. Under this alternative, no remedial efforts would be conducted to remove, treat, or otherwise lessen the toxicity, mobility, or affected volume of contaminated media. Only those site access restrictions that currently exist at SRS would be implemented under this alternative.

Access to SRS is controlled at primary roads by continuously manned barricades. Other roads entering the site are closed to traffic by gates or barriers. The entire SRS facility is surrounded by an exclusion fence, except along the Savannah River. The site is posted against trespassing under Federal and State statutes. Consequently, this alternative would satisfy short-term protectiveness of human health through the existing site access restrictions at SRS.

Under this alternative, radioactive decay would be the primary mechanism providing a reduction in ^{137}Cs concentrations within the soil and debris. The maximum concentration of ^{137}Cs within the KBPOP is 0.295 pCi/g. The remedial action target goal for ^{137}Cs is 0.0208 to 2.08 pCi/g. Based on the half-life of ^{137}Cs (30 years), the estimated time for radioactive decay to reduce the concentration of ^{137}Cs to the lower end of the target goal range, 0.0208 pCi/g, is approximately 115 years.

Long-term protectiveness of human health would be achieved for as long as existing site access restrictions are maintained or until remedial action target goals are achieved. Although site access restrictions are likely to be retained at SRS for the foreseeable future, the restrictions cannot be guaranteed for the length of time necessary for radioactive constituents to decay to levels at the lower end of the target goal range for ^{137}Cs. Therefore, whether this alternative can achieve long-term protectiveness of human health is partially dependent upon the final remedial action target goal for ^{137}Cs.

A low-permeability zone underlies the site. Soil leachability modeling and risk calculations show that groundwater constituent levels will not exceed MCLs within the next 1000 years. Therefore, no additional efforts would be taken under this alternative to contain KBPOP contamination or contaminated media. This alternative does not provide a mechanism for verifying whether contaminants leach to groundwater in the future.

This alternative would require no construction, specialized equipment, or technical specialists and could therefore be implemented immediately.

No capital costs are associated with this alternative. The NCP requires remedy reviews every five years for remedial actions that result in hazardous substances, pollutants, or contaminants remaining at the waste unit above levels that allow for unlimited use and unrestricted exposure. The only costs associated with this alternative would be a review of remedy every five years for 30 years. No other long-term operation and maintenance (O&M) costs would be associated with this alternative. Estimated costs associated with this alternative are summarized below.

Capital Costs	$ 0
O&M Costs	$280,000
Total Costs	$280,000

The development of costs for this alternative is provided in Appendix A.

3.3.3.2 Evaluation of Alternative 1

This alternative would be protective of human health as long as existing site access restrictions are maintained at SRS and would be protective of the environment since the clay layer (hardpan) provides a barrier to migration. However, neither the access restrictions nor the minimization of the leachability of the contaminants could be guaranteed in the future.

Additionally, the NCP requires that a No Remedial Action alternative be retained as a baseline alternative against which all other alternatives can be compared. Alternative 1 will be retained for detailed analysis.

3.3.4 Alternatives Under the General Response of Institutional Controls

Listed below are a description, screening comments, and evaluation of Alternative 2. Alternative 2 is the only alternative that is categorized under the general response of Institutional Controls.

3.3.4.1 Alternative 2: Access and Deed Restrictions

Under this alternative, the contaminated soil and debris would remain undisturbed as under Alternative 1. All access restrictions described under Alternative 1 would also be in place under this alternative. In addition, a fence would be constructed around the site and restrictions would be placed on the future uses of the site. The site would be periodically inspected and maintained.

The fence would prevent SRS workers from inadvertently entering the site area. Therefore, the short-term human exposure pathways would be reduced or eliminated under this alternative. Maintenance of the current cover over the debris would provide protection against fugitive dust. Four feet of fill at the KBPOP is adequate to provide protection for direct radiation from the site.

Limitations on future uses of the site would be filed with the local zoning authority. By controlling the future uses of the site, the long-term human exposure pathways would also be reduced by this alternative.

Contaminant toxicity, mobility, and volume would not be affected under this alternative. The concentration of radionuclides would decline by natural radioactive decay.

This alternative requires no specialized equipment or technology and could be implemented immediately.

The primary capital costs associated with this alternative involve the construction of the fence and fees and labor required for land use restrictions. Five year remedy reviews would also be required under this alternative. Estimated costs are summarized below.

Capital Costs	$ 20,000
O&M Costs	$280,000
Total Costs	$300,000

3.3.4.2 Evaluation of Alternative 2

This alternative would be protective of human health and the environment since a low-permeability zone underlies the site. Soil leachability modeling and risk calculations show that MCLs will not be exceeded in groundwater during the next 1000 years.

Access controls, such as fencing and restricted future use, provides better protection than the No Remedial Action alternative and eliminates or reduces human exposure pathways that result in carcinogenic risks exceeding 1×10^{-6} as calculated in the BRA. Therefore, Alternative 2 will be retained for detailed analysis.

3.3.5 Alternatives Under the General Response of Containment

Following is a description, screening, and evolution of Alternatives 3, 4 and 5, which fall under the containment category of general response actions.

3.3.5.1 Alternative 3: Soil Cover

Alternative 3 involves grading and clearing the site as necessary, and constructing a soil cover over the KBPOP. The soil cover would be a low-permeability cover with a minimum thickness of three feet and a nominal in-place saturated hydraulic conductivity of 1×10^{-5} cm/s or less. The soil cover would have an upper surface with a slope of three to five percent to promote surface water runoff and to minimize surface erosion. A topsoil layer having a minimum thickness of three to six inches would be placed on top of the soil cover. The topsoil would be seeded with native grasses to increase evapotranspiration. The topsoil layer would also protect the soil cover from damage due to erosion, frost, and burrowing animals.

The soil cover would be placed over an area of approximately 2,600 m^2 (28,000 ft^2). The soil cover dimensions would be approximately 69 feet by 410 feet, which extends five feet beyond each side of the KBPOP.

The soil cover would function as a physical barrier to prevent direct human exposure to soil-borne contamination and would therefore be protective of human health and the environment. Only three feet of soil cover is required to reduce the annual effective dose associated with continuous exposure to the ^{137}Cs in the KBPOP by over 99 percent and within regulatory and DOE limits. The three feet of soil cover would provide adequate protection from direct radiation from the site. In addition, the *soil cover* would minimize infiltration and subsequent leaching of contamination from unsaturated soil to the groundwater.

Soil cover construction is a straight-forward process requiring minimal, if any, disturbance of contaminated KBPOP soil. Consequently, short-term risks to the health of remedial workers would be minimal. If properly constructed and maintained, soil covers can provide effective long-term protection to human health and the environment.

Alternative 3 would not involve any form of treatment that would reduce the toxicity, mobility or volume of contaminants or contaminated media; however, the soil cover would effectively reduce contaminant mobility by minimizing infiltration and contaminant leaching, thereby reducing inherent risks associated with the contamination. Additionally, the clay layer (hardpan) beneath the site has proven to be an adequate barrier to contaminant migration.

In general, soil cover construction is readily implementable. Alternative 3 would use readily available materials and conventional earth moving equipment. Numerous qualified contractors who can competitively bid on the design and construction of a soil cover are available. Soil covers have been commonly used at other low-level radioactive and mixed water sites and generally do not elicit public concerns.

Costs associated with Alternative 3 include the labor and materials needed to construct the soil cover as well as operation and maintenance for 30 years. These costs include a review of remedy every five years for 30 years as required by the NCP. Five year remedy reviews are required for remedial actions that result in hazardous substances, pollutants, or contaminants remaining at the waste unit above levels that allow for unlimited use and unrestricted exposure. Estimated costs associated with Alternative 3 are summarized below:

Capital Costs	$300,000
O&M Costs	$330,000
Total Costs	$630,000

The development of costs for this alternative is presented in Appendix A.

3.3.5.2 Alternative 4: Excavate Debris and Dispose at E-Area Vaults or Soil Consolidation Facility; Soil Cover

Alternative 4 enhances the containment strategy presented in Alternative 3 by removing contaminated debris from the site.

The debris and covering soil would be excavated from the site by backhoe or similar means. The debris would be mechanically separated from the soil and disposed at the E-Area vaults or the Soil Consolidation Facility. The soil would be returned to the excavation, which would be backfilled to grade. A soil cover would be constructed over the site as described under Alternative 3.

Alternative 4 would not involve any form of treatment to reduce the toxicity, mobility or volume of contaminants. However, the source of contamination would be removed from the site. Therefore, the volume of contamination actually remaining at the site would be reduced by this alternative.

This alternative would provide all of the long-term protections of Alternative 3, plus the additional long-term protection provided by debris removal. However, this alternative would involve higher levels of short-term risk because of the increased waste handling that would be required.

Excavation and disposal are responsible for the majority of the cost associated with this alternative. All costs associated with Alternative 3 are also retained in this alternative. Estimated costs associated with Alternative 4 are summarized below:

Capital Costs	$10,400,000
O&M Costs	$330,000
Total Costs	$11,000,000

3.3.5.3 Alternative 5: Excavate Debris and Dispose at Envirocare Facility; Soil Cover

Alternative 5 also enhances the containment strategy presented in Alternative 3 by removing contaminated debris from the site.

The debris and covering soil would be excavated from the site by backhoe or similar means. The debris would be mechanically separated from the soil and transported to the Envirocare Facility for disposal. The clean soil would be returned to the excavation, which would be backfilled to grade. A soil cover would be placed over the site as described under Alternative 3.

Alternative 5 would not involve any form of treatment to reduce the toxicity, mobility or volume of contaminants. However, the source of contamination would be removed from the site. Therefore, the volume of contamination actually remaining at the site would be reduced by this alternative.

This alternative would provide all of the long-term protections of Alternative 3, plus the additional long-term protection provided by debris removal. However, this alternative would involve higher levels of short-term risk because of the increased waste handling that would be required. This alternative would require more extensive handling of wastes than Alternative 4 because the waste must be transported to the Envirocare facility.

Excavation and disposal are responsible for the majority of the cost associated with this alternative. All costs associated with Alternative 3 are also retained in this alternative. Estimated costs associated with Alternative 5 are summarized below:

Capital Costs	$12,800,000
O&M Costs	$330,000
Total Costs	$13,000,000

3.3.5.4 Evaluation of Alternatives Under the General Response of Containment

Alternatives 3, 4 and 5 are each potentially effective at protecting human health and the environment. The short-term risk to human health is greatest under Alternative 5, while Alternative 3 presents only slight short-term risk. The potential risks to workers can be maintained within acceptable levels under each alternative as long as there is strict adherence to the project health and safety plan. Neither alternative should present any significant threat to the community.

Each alternative reduces the mobility of contaminants. Alternatives 4 and 5 reduce the volume of contaminated material at the site, but replace the removed material at alternative locations.

Each method is readily implementable, however, selection of an acceptable and appropriate disposal facility may present some hindrances for Alternative 4.

Alternatives 4 and 5 also requires significantly higher levels of cost than Alternative 3.

Because Alternative 3 provides sufficient protection at significantly lower cost than Alternatives 4 and 5, Alternative 3 was maintained for further consideration and Alternatives 4 and 5 were eliminated.

3.3.6 Alternatives Under the General Response of In-Situ Treatment

This subsection contains a description, screening, and evaluation of Alternatives 6, 7 and 8.

3.3.6.1 Alternative 6: In-Situ Stabilize Soil and Debris

Alternative 6 involves in-situ grouting the KBPOP soil. In-situ grouting can be accomplished by conventional trackhoes and tillers mounted to trackhoes, jet grouting, or auguring. Care would be required to minimize the generation of airborne particulate during processing. This could be accomplished by applying dust suppressants, monitoring for airborne particulate, and strict adherence to project work plans. In-situ grouting would begin at one end of the KBPOP and progress along the site until all soil is treated.

Alternative 6 would be protective of human health and the environment. Grouting of the contaminated KBPOP soil would provide long-term protection by significantly reducing the mobility of radioactive contaminants for several hundred years.

In-situ stabilization of soil is a relatively straight-forward process; however, due to the increased handling of contaminated media, the potential for elevated short-term risk to the health of remedial workers is increased. Exposure can be minimized and maintained well below acceptable levels with the use of proper protective clothing, scheduled monitoring of area radiation and airborne particulate levels, and strict adherence to the project health and safety plan.

Alternative 6 would involve in-situ stabilization which is an active form of treatment that would reduce the mobility of contaminants in soil. One disadvantage of S/S technologies is that the volume of contaminated media is increased due to the addition of additives such as grout; however, the treated media would be contained within the KBPOP and would not add to the overall volume of waste to be managed. Grouting would reduce contaminant mobility, thereby reducing the inherent risk to the environment and human health.

In general, in-situ stabilization should be readily implementable. Alternative 6 would likely require readily available reagents (e.g., Portland cement, bentonite, silicate), and the use of conventional or non-conventional delivery systems. Implementation of treatment could be hindered by the presence of debris. The debris could cause incomplete treatment of contaminated materials, and special grouting procedures may need to be developed. Grouting procedures would be evaluated during the remedial design and, if necessary, special procedures would be developed at that time. Extensive decontamination of equipment would be required since the process would be conducted in-situ. Numerous qualified contractors are available that can competitively bid on project design and construction. In-situ grouting in conjunction with a soil cover has been used at other waste sites, and generally does not elicit public concerns.

Costs associated with Alternative 6 include the labor and materials needed to grout the KBPOP soil. Also included in the costs is the operation and maintenance of the soil cover for 30 years. These costs include a review of remedy every five years for 30 years as required by the NCP. Five year remedy reviews are required for remedial actions that result in hazardous substances, pollutants, or contaminants remaining at the waste unit above levels that allow for unlimited use and unrestricted exposure. Estimated capital and O&M costs associated with Alternative 6 are summarized below.

Capital Costs	$1,700,000
O&M Costs	$ 300,000
Total Costs	$2,000,000

Costs for this alternative are provided in Appendix A.

3.3.6.2 Alternative 7: Excavate Debris and Dispose Off-Unit; In-Situ Solidification/Stabilization of Soil; Backfill; Soil Cover

Alternative 7 provides the same general in-situ treatment strategy as presented in Alternative 6. However, under Alternative 7, the debris would be removed from the unit prior to treatment. Once the debris was removed and disposed off-unit, the excavation would be backfilled to grade and then in-situ stabilized as described under Alternative 6. After treatment is completed, a soil cover would be placed over the site. Off unit disposal would be at either the Soil Consolidation Facility or the E-Area Vaults.

Alternative 7 would provide protection of human health and the environment by removing the source of contamination from the site and then solidifying any residual contamination, significantly reducing the mobility of the materials in the KBPOP soil.

Excavation and waste handling would present short-term risks to on-site workers. In-situ treatment would also present limited short-term risks. All of the short-term risks presented by this alternative could be minimized through adherence to a project health and safety plan.

The total volume of contaminated material at the site would be reduced by removal of the debris. However, the debris would only be moved to an alternative location. The volume of contaminated soil remaining at the site would then be increased by the solidification process.

Costs associated with Alternative 7 include labor and equipment required to excavate, segregate and dispose of the site debris. In addition, the costs of in-situ stabilization of site soils and construction of a soil cover contribute to the overall alternative costs. Site and soil cover maintenance and five year remedy reviews are also included in the cost estimate provided below.

Capital Costs	$13,000,000
O&M Costs	$ 300,000
Total Costs	$13,000,000

3.3.6.3 Alternative 8: In-Situ Vitrification; Soil Cover

Alternative 8 involves the in-situ vitrification of the KBPOP. Upon completion of in-situ vitrification, a soil cover would be placed over the site as described under Alternative 3. Intense heat is generated within the soil matrix until the matrix becomes vitrified. When the heating energy is removed, the molten soil or melt cools into a solid, glassy matrix.

To initiate the melting process, a conductive mixture of flaked graphite and glass frit is typically placed between the electrodes to act as a starter path for the electric circuit. Because SRS soil have been found to be deficient in CaO, Na_2O, and K_2O, a flux of 5 to 10 wt% sodium carbonate may be necessary to vitrify KBPOP soil. Based upon results of bench-scale studies conducted on SRS soil, the soil amendments must be pre-mixed into the soil to the desired treatment depth to ensure adequate penetration of the melt (EPA, 1992). This would involve the in-situ mixing of amendments using conventional earth moving equipment. A unit-specific treatability study would be conducted to determine amendment requirements specific to KBPOP soil. To minimize equipment downtime, all soil would be pretreated prior to initiating in-situ vitrification. When pretreatment of soil is completed, the vitrification unit electrodes would be inserted to the desired depth and current passed between the electrodes. The vitrification process would be repeated until all KBPOP soil are processed. At the conclusion of the vitrification process, a soil cover would be constructed over the KBPOP as described under Alternative 3.

Alternative 8 would be protective of human health and the environment. The vitrified soil would form a very hard, durable, glassy, solid monolith that would be very resistant to leaching and is considered a permanent remediation solution (Oma, 1994). Residual organic compounds present would be permanently destroyed, volatile compounds would be contained in the off-gas treatment system, and remaining inorganic constituents would be chemically incorporated in the resulting monolith. The monolith would be capable of withstanding long-term environmental exposure without effect. In addition, the soil cover would function as a physical barrier to deter direct human contact with the subsurface monolith.

In-situ vitrification of soil at the KBPOP would be a relatively involved, complex process. A treatability study would be warranted to determine optimum recipe of amending soil, followed by pretreatment of soil. Pretreatment of soil would require unit preparations similar to those discussed under Alternative 6. Further unit preparation would be required to support the in-situ vitrification process. Short-term risk to the health of remedial workers would increase (over Alternative 3) with the additional handling and processing of contaminated media. The use of protective measures (e.g., barrier soil, dust collection hood, off-gas collection hood), would minimize remedial worker exposure to airborne emissions and maintain their exposure below acceptable levels. Additional safety measures include the use of proper protective clothing, scheduled monitoring of area radiation and airborne particulate levels, and strict adherence to the project health and safety plan. Short- and long-term risks associated with soil cover construction are discussed under Alternative 3.

In-situ vitrification would treat contaminated soil, resulting in reduced contaminant mobility and contaminated media volume. Because the contaminants would be permanently immobilized, Alternative 8 would greatly reduce the inherent risk associated with KBPOP contaminated media. Although in-situ vitrification would reduce the volume of contaminated media (i.e., eliminate pore space in soil matrix), the monolith would remain within the KBPOP and would not lessen the overall volume of waste to be managed.

Even though in-situ vitrification has undergone extensive testing and is considered potentially feasible for a variety of applications, in-situ vitrification may be considered an innovative technology due to limited application on large-scale projects and limited number of large-scale systems. Two large-scale in-situ vitrification systems have been designed and fabricated. One of the systems was designed for remediating industrial waste sites, and the other system was designed for testing on DOE radioactive and mixed waste sites. The large-scale DOE system is designed to accommodate electrode separations of 3.5 to 5.5 m (11.5 to 18 ft) and treatment depths up to 9.1 m (30 ft; Oma, 1994). Although the availability of the DOE large-scale system may be limited, in-situ vitrification should be implementable.

Soil amendments (sodium carbonate) should be readily available. Although the rigs needed to deliver the reagents is not considered conventional, there should be a number of contractors available that can procure the required equipment. In addition, conventional earth moving equipment would be required (e.g., backhoes, dump trucks, bull dozers, compactors) to backfill the KBPOP at the conclusion of in-situ vitrification operations. Only a limited number of qualified contractors are available that can design and construct an in-situ vitrification system for use at a USDOE waste unit (Tixier, 1995). In-situ vitrification used in conjunction with a soil cover would not be expected to elicit great public concerns. Implementability of soil cover construction is discussed under Alternative 3.

Costs associated with Alternative 8 include the labor and materials needed to pretreat soil in-situ, vitrify KBPOP soil in-situ, and to construct a soil cover over the KBPOP. Also included in the costs is the operation and maintenance of the soil cover for 30 years. These costs include a review of remedy every five years for 30 years as required by the NCP. Five year remedy reviews are required for remedial actions that result in hazardous substances, pollutants, or contaminants remaining at the waste unit above levels that allow for unlimited use and unrestricted exposure. Estimated costs associated with Alternative 7 are summarized below:

Capital Costs	$17,000,000
O&M Costs	$ 300,000
Total Costs	$17,000,000

3.3.6.4 Evaluation of Alternatives Under the General Response of In-Situ Treatment

Alternatives 6, 7 and 8 are potentially effective at protecting human health and the environment. The short-term risk to human health is greatest under Alternatives 7 and 8 since they involve contact with debris and much greater processing of contaminated soil than Alternative 6. The potential increase in health risks to remedial workers can be maintained within acceptable limits under Alternatives 6 and 8 as long as there is strict adherence to the project health and safety plan. Alternatives 6, 7 and 8 should not pose significant health risk to the public.

Alternatives 6, 7 and 8 all involve treatment of contaminated media that reduces contaminant mobility. Alternative 8 would most effectively reduce contaminant mobility since contaminants would be chemically and physically bound within the vitrified matrix permanently. In-situ grouting proposed under Alternatives 6 and 7 would result in an increase in contaminated media volume, whereas vitrification proposed under Alternative 8 would reduce contaminated media volume. However, in each case, the net volume of waste to be managed would not be affected.

Alternatives 6 and 7 require more conventional equipment and manpower and are more easily implemented than Alternative 8. The time period to implement and complete Alternatives 6 and 7 would be short as compared to implementing and completing Alternative 8. In-situ vitrification proposed under Alternative 8 is more difficult to implement than Alternatives 6 and 7 because of the very limited availability of an in-situ vitrification unit, the need to pretreat soil using specialty equipment, and the need for a very limited number of highly skilled and trained operators to conduct process operations. The time period required to implement and complete Alternative 8 would be much greater than Alternatives 6 and 7.

Estimated total present worth costs of Alternative 8 is much more than the estimated total present worth costs associated with alternatives 6 and 7.

Although vitrification of soil would be much more effective in immobilizing soil-borne contamination than treating using a S/S technology, the apparent need to pretreat the soil prior to vitrification significantly lessens the feasibility of Alternative 8 as an in-situ treatment alternative. Based upon bench-scale testing of SRS soil, KBPOP soil will likely require pretreatment for the addition sodium carbonate. Pretreating of the soil would be very costly and would significantly prolong the time required to complete remedial actions at the KBPOP waste unit. In addition, Alternative 8 is clearly less implementable and much more costly than Alternatives 6 and 7. Alternative 8 will therefore be rejected from further consideration on the basis of implementability and cost. Alternative 7 will also be rejected because it provides only slightly higher long-term protection than Alternative 6 while presenting higher short-term risks and higher costs.

3.3.7 Alternatives Under the General Response of Ex-Situ Treatment

Following are descriptions, screening, and evaluations of Alternatives 9, 10 and 11.

3.3.7.1 Alternative 9: Excavate Soil and Debris; Dispose Debris Off-Unit; Stabilize Soil Ex-Situ, Backfill; Soil Cover

Alternative 9 involves the excavation and ex-situ stabilization of soil and off-site disposal of debris. Upon completion of ex-situ stabilization, treated soil would be placed in the KBPOP, and a soil cover would be placed over the site as described under Alternative 3. The equipment needed to conduct ex-situ grouting of soil can vary from conventional mixing equipment (e.g., pug mill, mixers) to heating and extruding equipment, depending upon the type of S/S reagents used. The S/S reagent best suited to treat the soil would be based upon the results of a unit-specific S/S treatability testing. For the purpose of this study, it will be assumed that the S/S reagent selected would require conventional treatment equipment.

Using a trackhoe, the KBPOP soil and debris would be excavated to a depth of four feet. Any visible debris extending below a depth of four feet will also be excavated; however, the cost estimate is based on a total depth of four feet.

The trackhoe would start at one end of the KBPOP and would gradually progress along the edges and toward the middle until all the specified soil and debris are removed. Excavated soil and debris would be staged at a protective area adjacent to the KBPOP prior to processing. The debris would then be mechanically separated from the soil and transported for disposal off site. The soil would then be mixed with the S/S reagents at predetermined ratios and the soil would be placed back into the KBPOP. Once excavation and grouting activities are complete, the KBPOP would be backfilled with treated material, followed by the construction of a soil cover over the KBPOP as described under Alternative 3.

Care would be required to minimize the generation of airborne particulates during processing. This could be accomplished by applying dust suppressants, monitoring for airborne particulates; and strict adherence to project work plans.

Alternative 9 would be protective of human health and the environment. The soil cover would function as a physical barrier to prevent direct human exposure to soil-borne contamination and would minimize infiltration and subsequent leaching of contamination from unsaturated soil to the groundwater. If properly constructed and maintained, soil covers can provide effective long-term protection of human health and the environment. Grouting of the KBPOP soil would provide an added measure of long-term protection by immobilizing the COCs associated with KBPOP soil. Removal of the debris from the site would further protect human health and the environment by removing the source of contamination.

Ex-situ stabilization of soil is a relatively straight-forward process; however, due to the increased handling of contaminated media, there would be a potential for elevated short-term health risk to remedial workers. With the proper use of protective clothing, scheduled monitoring of area radiation and airborne particulate levels, and strict adherence to the project health and safety plan, remedial worker exposure can be minimized and maintained below acceptable levels. Ex-situ grouting should not pose any significant health risk to the public. Short- and long-term risks associated with soil cover construction are discussed under Alternative 3.

Costs associated with Alternative 9 include the labor and materials needed for pre-treatment the soil prior to excavation for waste handling purposes, excavation of the KBPOP soil and debris, treatment of soil, transport and disposal of debris, and construction of a soil cover over the KBPOP. Also included in the costs is the operation and maintenance of the soil cover for 30 years. These costs include a review of remedy every five years for 30 years as required by the NCP. Five year remedy reviews are required for remedial actions that result in hazardous substances, pollutants, or contaminants remaining at the waste unit above levels that allow for unlimited use and unrestricted exposure. Estimated costs associated with Alternative 9 are summarized below.

Capital Costs	$13,000,000
O&M Costs	$ 300,000
Total Costs	$13,000,000

3.3.7.2 Alternative 10: Excavate KBPOP Soil and Debris, Ex-Situ Vitrify Soil, Backfill Treated Soil into KBPOP; Soil Cover; Dispose Debris Off-Site

Alternative 10 involves the excavation and ex-situ vitrification of the soil. Upon completion of ex-situ vitrification, the vitrified soil would be placed back into the KBPOP. The KBPOP would be backfilled and compacted to grade, and a soil cover would be placed over the site as described under Alternative 3. Debris would be segregated from soil prior to treatment and disposed off-site.

Ex-situ vitrification of soil involves the vitrification of contaminated media in a vitrification unit separate from where the contaminated media is located. Initially, an ex-situ vitrification unit would be specifically designed to accommodate KBPOP contaminated media. The minimum time required to design and construct a Terra-Vit portable ex-situ vitrification unit would be at least one year (Tixier, 1995). Treatability testing would be conducted as required to support unit design. When designed, the vitrification unit and support equipment would be mobilized to the KBPOP waste unit, constructed and tested.

Prior to excavation, soil would be treated to ensure optimal waste handling characteristics. Subsequently, a trackhoe would be used to excavate KBPOP soil. The trackhoe would start at one end of the pit and would gradually progress along the edges and toward the middle of the pit until all of the soil to 15 ft is removed. Pre-treated excavated soil would be staged at a protective area adjacent to the KBPOP prior to processing.

Because SRS soil have been found to be deficient in the amount of CaO, Na_2O, and K_2O, it may be necessary to amend the soil with a flux of five to ten percent by weight sodium carbonate in order to vitrify KBPOP waste unit soil (EPA, 1992). A unit-specific treatability study would be conducted to determine if soil amendments are required.

KBPOP soil will be excavated, amended, and processed through the vitrification unit with the vitrified soil being returned to the pit. The vitrification process would continue until all KBPOP soil are processed. At the conclusion of the vitrification process, the remaining capacity of the KBPOP would be backfilled and compacted to grade, and a soil cover would be constructed over the KBPOP as described under Alternative 3.

Alternative 10 would be protective of human health and the environment. The vitrified soil would form a very hard, durable, glassy, solid monolith that would be very resistant to leaching and is considered a permanent remediation solution (Oma, 1994). Organic compounds present would be permanently destroyed, volatile compounds would be contained in the off-gas treatment system and remaining inorganic constituents would be chemically incorporated in the resulting melt. The melt should be capable of withstanding long-term environmental exposure without effect. In addition, the soil cover would function as a physical barrier to deter direct human contact with the subsurface monolith.

Ex-situ vitrification of soil at the KBPOP would be a relatively involved, complex process. Vitrification of KBPOP soil would be preceded by design, construction, and testing of an ex-situ vitrification unit. In addition, a treatability study would be warranted to determine design requirements and the optimum recipe for amending soil. Extensive unit preparation would also be required to support the ex-situ vitrification process.

Short-term risk to the health of remedial workers would exist due to the extensive handling and processing of contaminated media. The use of protective measures (e.g., barrier soil, off-gas collection hood), would minimize remedial worker exposure to airborne emissions and maintain their exposure below acceptable levels. Additional safety measures include the use of proper protective clothing, scheduled monitoring of area radiation and airborne particulate levels, and strict adherence to the project health and safety plan. Ex-situ vitrification should not pose any significant health risk to the public. Short-and long-term risks associated with soil cover construction are discussed under Alternative 3.

Ex-situ vitrification would treat contaminated soil, resulting in significantly reduced contaminant mobility and contaminated media volume. Alternative 10 would greatly reduce the inherent risk associated with KBPOP contaminated media since the contaminants would be permanently immobilized within the glass matrix. Although ex-situ vitrification would reduce the volume of contaminated media, the vitrified product would remain within the KBPOP. The removal of debris from the site would reduce the volume of waste at the KBPOP, but would only transfer the material to another location.

Ex-situ vitrification has undergone extensive testing and is frequently used for treating high-level radioactive waste; however, on-unit vitrification of low-level or mixed waste using a portable melter may be considered an innovative technology since there has been limited application of ex-situ vitrification on large-scale projects and there are no large-scale systems available to design and construct a Terra-Vit melter (Tixier, 1995). Despite these limitations, Alternative 10 should be implementable. Ex-situ vitrification using a portable Terr-Vit melter has been demonstrated on a comparable project (Chapman, 1993). Although ex-situ vitrification is a relatively innovative technology, it would not be expected to elicit great public concerns. Implementability of soil cover construction is discussed under Alternative 3.

Costs associated with Alternative 10 include the labor and materials needed to design and construct a portable ex-situ vitrification system, to pre-treat the soil and subsoil for waste handling purposes, to evacuate and vitrify the soil, to construct a soil cover over the KBPOP, and to segregate and dispose of the debris. Also included in the costs is the operation and maintenance of the soil cover for 30 years. These costs include a review of remedy every five years for 30 years as required by the NCP. Estimated costs associated with Alternative 10 are summarized below.

Capital Costs	$17,000,000
O&M Costs	$ 300,000
Total Costs	$17,000,000

3.3.7.3 Alternative 11: Excavate Soil and Debris; Solidify Soil and Debris; Backfill Treated Material; Soil Cover

Alternative 11 involves the excavation of soil and debris and ex-situ stabilization of soil. Upon completion of ex-situ stabilization, debris and treated soil would be placed in the KBPOP, and a soil cover would be placed over the site as described under Alternative 3. The equipment needed to conduct ex-situ grouting of soil can vary from conventional mixing equipment (e.g., pug mill, mixers) to heating and extruding equipment, depending upon the type of S/S reagents used. The S/S reagent best suited to treat the soil would be based upon the results of a unit-specific S/S treatability testing. For the purpose of this study, it will be assumed that the S/S reagent selected would require conventional treatment equipment.

Using a trackhoe, the KBPOP soil and debris would be excavated to a depth of four feet. Any visible debris extending below a depth of four feet will also be excavated; however, the cost estimate is based on a total depth of four feet.

The trackhoe would start at one end of the KBPOP and would gradually progress along the edges and toward the middle until all of the specified soil and debris are removed. Excavated soil and debris would be staged at a protective area adjacent to the KBPOP prior to processing. The staged materials would be mixed with the S/S reagents at predetermined ratios and the treated product would be placed back into the KBPOP. Once excavation and grouting activities are complete, the KBPOP would be backfilled with treated material, followed by the construction of a soil cover over the KBPOP as described under Alternative 3.

Care would be required to minimize the generation of airborne particulates during processing. This could be accomplished by applying dust suppressants, monitoring for airborne particulates, and strict adherence to project work plans.

Alternative 11 would be protective of human health and the environment. The soil cover would function as a physical barrier to prevent direct human exposure to soil-borne contamination and would minimize infiltration and subsequent leaching of contamination from unsaturated soil to the groundwater. If properly constructed and maintained, soil covers can provide effective long-term protection of human health and the environment. Grouting of the KBPOP soil and debris would provide an added measure of long-term protection by immobilizing the COCs associated with KBPOP soil.

Ex-situ stabilization of soil is a relatively straight-forward process; however, due to the increased handling of contaminated media, there would be a potential for elevated short-term health risk to remedial workers. With the proper use of protective clothing, scheduled monitoring of area radiation and airborne particulate levels, and strict adherence to the project health and safety plan, remedial worker exposure can be minimized and maintained below acceptable levels. Ex-situ grouting should not pose any significant health risk to the public. Short- and long-term risks associated with soil cover construction are discussed under Alternative 3.

Costs associated with Alternative 11 include the labor and materials needed to pre-treat the soil prior to excavation for waste handling purposes, excavation and treatment of the KBPOP soil and debris, and to construct a soil cover over the KBPOP. Also included in the costs is the operation and maintenance of the soil cover for 30 years. These costs include a review of remedy every five years for 30 years as required by the NCP. Five year remedy reviews are required for remedial actions that result in hazardous substances, pollutants, or contaminants remaining at the waste unit above levels that allow for unlimited use and unrestricted exposure. Estimated costs associated with Alternative 11 are summarized below.

Capital Costs	$3,100,000
O&M Costs	$ 300,000
Total Costs	$3,400,000

Costs for this alternative are provided in Appendix A.

3.3.7.4 Evaluation of Alternatives Under the General Response of Ex-Situ Treatment

Alternatives 9, 10 and 11 are potentially effective at protecting human health and the environment. The short-term risk to human health is greatest under Alternative 10 since it involves greater processing of contaminated material than either Alternatives 9 or 11. The potential increase in health risks to remedial workers can be maintained within acceptable limits under all three of these alternatives as long as there is strict adherence to the project health and safety plan. Alternatives 9, 10 and 11 should not pose any significant health risk to the public.

Alternatives 9, 10 and 11 involve treatment of contaminated media that reduces contaminant mobility. In terms of effectiveness, Alternative 10 would most effectively reduce contaminant mobility since it would chemically and physically immobilize contaminants permanently within a vitrified matrix.

Ex-situ grouting proposed under Alternatives 9 and 11 would result in an increase in contaminated media volume, whereas ex-situ vitrification proposed under Alternative 10 would reduce contaminated media volume.

Alternatives 9, 10 and 11 would require conventional excavation equipment and manpower. The time to implement and complete the remedial alternative would be shortest under Alternatives 9 and 11. Ex-situ vitrification proposed under Alternative 10 is the most difficult technology to implement because a portable vitrification unit must first be designed, constructed, and tested before it can be used to treat soil. In addition, operation of ex-situ vitrification equipment would require the services of a very limited number of highly skilled and trained operators to conduct process operations. The time required to implement and complete Alternative 10 would be much greater than for Alternatives 9 and 11.

The estimated present worth cost to treat KBPOP soil by vitrification is much higher than the cost of treating the waste by grouting. This disparity in costs is due to the high cost of vitrification system design, construction, and operation.

Of the three alternatives considered for the general response of ex-situ treatment, Alternative 11 will be retained for detailed analysis. Although Alternative 9 is implementable, it involves higher cost and more potential implementation problems and does not provide significantly more protection than Alternative 11. Alternative 10 will be rejected on the basis of implementability and cost.

3.3.8 Alternatives Under the General Response Off-Site Disposal

This subsection contains a description, screening, and evaluation of Alternatives 12 and 13.

3.3.8.1 Alternative 12: Excavate KBPOP, Dispose at the E Area Vaults or the SRS Soil Consolidation Facility, if Applicable

Alternative 12 involves the excavation of KBPOP soil and disposal at either the E Area Vaults or conceptual SRS Soil Consolidation Facility. The Soil Consolidation Facility is being discussed with agencies as an alternative strategy for off-unit disposal. The Soil Consolidation Facility would be a central disposal facility for SRS generated radiologically contaminated wastes.

Alternative 12 would be protective of human health and the environment. Alternative 12 would permanently remove all soil-borne contamination known to be present at the KBPOP. Short-term risk to the health of remedial workers would exist due to the extensive handling and processing of contaminated media. With the use of protective measures such as the use of proper protective clothing and equipment, scheduled monitoring of area for radiation and airborne particulate levels, and strict adherence to the project health and safety plan, remedial worker exposure can be maintained within acceptable levels.

Alternative 12 would not involve any form of treatment that would result in a reduction of contaminant toxicity, mobility, or volume.

Off-site disposal of low-level radioactive or mixed wastes is implementable; however, it requires extensive waste handling.

Costs associated with Alternative 12 include the labor and materials needed to pre-treat soil and subsoil for waste handling purposes, to excavate the wastes, to treat the wastes following excavation for packaging and disposal requirements, to transport the wastes, and to dispose of KBPOP soil. A review of remedy would not be required for KBPOP soil under this alternative because concentrations of constituents remaining at the KBPOP would not exceed the RGOs. In addition, there are no long-term operation and maintenance costs associated with Alternative 12 since it would not involve the construction of a soil cover. Estimated costs associated with Alternative 12 are summarized below.

Capital Costs	$16,000,000
O&M Costs	$ 0
Total Costs	$16,000,000

Costs for this alternative are provided in Appendix A.

3.3.8.3 Alternative 13: Excavate KBPOP, Dispose of Soil at the Envirocare Facility

Alternative 13 is generally the same as Alternative 12 with the exception of the location of the disposal facility and the costs for disposal.

The Envirocare facility is certified to accept low-level radioactive wastes and mixed wastes from various sources including DOE facilities and has available capacity to accept 4.4E4 m^3 (1.5E6 ft^3; 5.5E4 yd^3) of material. A number of transporters are available that are certified and qualified to transport low-level radioactive and mixed wastes. There is a potential for public resistance to Alternative 13 since there is potential risk to the public during waste transport. Approximately 300 rail gondolas or 230 truckloads of contaminated soil would be transferred to Utah from the SRS assuming that gondolas and haul truck capacities are 34 m^3 (1,200 ft^3; 44 yd^3) and 13.8 m^3 (486 ft^3; 18 yd^3), respectively.

Costs associated with Alternative 13 include the labor and materials needed to excavate, transport and dispose of KBPOP material. A review of remedy would not be required for KBPOP soil under this alternative since the unit soil would contain no hazardous substances, pollutants, or contaminants above concentration-based remediation goals. In addition, there are no long-term operation and maintenance costs associated with Alternative 13 since it would not involve the construction of a soil cover. Estimated costs associated with Alternative 13 are summarized below.

Capital Costs	$21,000,000
O&M Costs	$ 0
Total Costs	$21,000,000

3.3.8.4 Evaluation of Alternatives Under the General Response of Off-Unit Disposal

Off-unit disposal Alternatives 12 and 13 are potentially effective for protecting human health and the environment. The potential increase in health risks to remedial workers can be maintained within acceptable limits under these alternatives as long as there is strict adherence to the project health and safety plan. The short-term risk to human health is greater under Alternative 13 because Alternative 13 would involve transport of contaminated soil greater than 3,200 km (2,000 mi) to the Envirocare facility, as opposed to disposing of the soil on SRS property under Alternative 12. The greatest risk to the public would most likely be in the form of traffic-related accidents.

The estimated present worth cost of Alternative 13 is higher than the cost of Alternative 12. The difference in present worth costs are attributed to higher disposal costs associated with the Envirocare Facility and transportation costs.

Alternatives 12 and 13 are both effective for protecting human health and the environment, and are implementable. While both alternatives would permanently remove contaminated soil from the KBPOP , Alternative 13 involves an increased risk to human health and the possible opposition of the public to long-distance transport to the Envirocare facility. Because Alternative 13 involves significantly greater cost than Alternative 12, it will be rejected from further consideration.

3.4 SUMMARY OF KBPOP ALTERNATIVE SCREENING

In this section, the results of screening potential remedial alternatives will be provided. Table 3.1 summarizes each alternative, its status, and the reasons for its status. The only No Remedial Action alternative was retained as required by the NCP. Three containment alternatives were evaluated; Alternative 3 (Soil Cover) was retained for detailed analysis. Of the in-situ treatment alternatives in -situ stabilization of soil and debris (Alternative 6) was retained and Alternatives 7 and 8 were rejected on the basis of implementability and cost. Of the ex-situ treatment alternatives, ex-situ stabilization of soil and debris (Alternative 10) was retained and Alternative 9 was rejected on the basis of effectiveness and cost. Of the two off-site disposal alternatives, disposal at the E-Area Vaults or the Soil Consolidation Facility (Alternative 11) was retained and Alternative 12 (disposal at the Envirocare facility) was rejected on the basis of cost. The retained KBPOP remedial alternatives will undergo detailed analysis in Section 4.

The following alternatives were retained for further analysis:

Alternative 1:	No Remedial Action
Alternative 2:	Access and Deed Restrictions/Notifications
Alternative 3:	Soil Cover
Alternative 6:	In-Situ Solidification of Soil & Debris, Soil Cover
Alternative 11:	Excavate soil and debris, solidify/stabilize soil, backfill treated soil and debris; soil cover
Alternative 12:	Excavation of Debris and Soil, Disposal in E-Area Vaults or Soil Consolidation Facility, if applicable.

3.5 ANALYSIS OF GROUNDWATER NO REMEDIAL ACTION ALTERNATIVE

No remedial actions would be conducted under this alternative, and no limitations would be placed on future uses of the site. Reduction of contamination levels would occur through natural processes.

The RI concluded that the KBPOP is not impacting groundwater. Constituents were not observed to have migrated horizontally and clayey zones directly underneath the base of the pit would limit vertical migration potential. The data was interpreted to indicate that any leaching from KBPOP has not impacted the groundwater. Therefore, groundwater will not be addressed as part of the KBPOP activities.

A summary of the groundwater alternatives presented in Section 3.2 is presented in Table 3.2.

Table 3.1
Screening of Alternatives for Soil Remediation at the K-Area Bingham Pump Outage Pit, Savannah River Site, South Carolina

General Response/Alternative	Effectiveness	Implementability	Budgetary Cost[1]	Status
NO REMEDIAL ACTION				
1. No remedial action	Contamination reduced only through natural attenuation. Current risks are below 1E-4 level.	This alternative is technically and administratively implementable.	$280,000	Retained
INSTITUTIONAL CONTROLS				
2. Access and deed restrictions/ notifications	Provides protection for current and future human exposure for all soil pathways except fugitive dust. Provides limited protection for ecological exposure.	The site is currently the property of the Savannah River site. This alternative is technically and administratively implementable.	$300,000	Retained
CONTAINMENT				
3. Soil cover	Installation of a soil cover would provide protection for all current and future human exposure pathways as well as surface ecological pathways. Soil cover construction could produce limited worker exposure.	Soil covers are an established technology. This alternative is technically and administratively implementable.	$630,000	Retained

Table 3.1 (Continued)
Screening of Alternatives for Soil Remediation at the K-Area Bingham Pump Outage Pit, Savannah River Site, South Carolina

General Response/Alternative	Effectiveness	Implementability	Budgetary Cost	Status
4. Excavate debris and dispose at E-Area vaults or Soil Consolidation Facility, backfill and soil cover	Removal of debris will eliminate primary human and ecological exposure pathways. Residual soil contamination would remain at the site. Soil contamination levels are not considered significant. Installation of a soil cover would provide protection for all current and future human exposure pathways as well as surface ecological pathways.	This alternative is technically and administratively implementable.	$11,000,000	Eliminated
5. Excavate debris and dispose at Envirocare, backfill and soil cover	Removal of debris will eliminate primary human and ecological exposure pathways. Residual soil contamination would remain at the site. Soil contamination levels are not considered significant. Installation of a soil cover would provide protection for all current and future human exposure pathways as well as surface ecological pathways.	This alternative is technically and administratively implementable.	$11,000,000	Eliminated

Table 3.1 (Continued)
Screening of Alternatives for Soil Remediation at the K-Area Bingham Pump Outage Pit, Savannah River Site, South Carolina

General Response/Alternative	Effectiveness	Implementability	Budgetary Cost	Status
IN-SITU TREATMENT				
6. In-situ solidification of soil and debris, soil cover	Reduces mobility of contaminants. Provides protection for all exposure pathways. Debris may prevent complete treatment of all material. Treatment may produce worker exposures.	In-situ solidification/stabilization is an established technology. Special techniques may be necessary to grout through debris, but this alternative is otherwise technically and administratively implementable.	$2,000,000	Retained
7. Excavation of debris, debris disposal off unit, in-situ stabilization/solidification of soil, soil cover	Removal of debris will eliminate primary human and ecological exposure pathways. Residual soil contamination would remain at site. Soil contamination levels are not considered significant. Treatment of soils would reduce mobility of contaminants. Soil cover would provide additional protection for soil exposure pathways. Excavation may produce worker exposures.	This alternative is technically and administratively implementable.	$13,000,000	Eliminated
8. Excavation of debris and dispose off-unit; in-situ vitrification of soil; soil cover	In-situ vitrification is effective for treatment of contaminated soils. Reduces mobility of contaminants. Provides protection for all exposure pathways.	This alternative is technically and administratively implementable. However, vitrification has only limited establishment as a treatment technology. Technology availability and acceptance may reduce implementability	$17,000,000	Eliminated

Table 3.1 (Continued)
Screening of Alternatives for Soil Remediation at the K-Area Bingham Pump Outage Pit, Savannah River Site, South Carolina

General Response/Alternative	Effectiveness	Implementability	Budgetary Cost	Status
EX-SITU TREATMENT				
9. Excavate debris and dispose off-unit, excavate soil and solidify/stabilize, backfill treated soil and soil cover	Removal of debris will eliminate primary human and ecological exposure pathways. Residual soil contamination would remain at site. Soil contamination levels are not considered significant. Treatment of soils would reduce mobility of contaminants. Soil cover would provide additional protection for soil exposure pathways. Excavation may produce worker exposures.	This alternative is technically and administratively implementable.	$13,000,000	Eliminated
10. Excavate debris and dispose off-unit, excavate soil and vitrify, backfill treated soil and soil cover	Removal of debris will eliminate primary human and ecological exposure pathways. Residual soil contamination would remain at site. Soil contamination levels are not considered significant. Treatment of soils would reduce mobility of contaminants. Soil cover would provide additional protection for soil exposure pathways. Excavation may produce worker exposures.	This alternative is technically and administratively implementable. However, vitrification has only limited establishment as a treatment technology. Technology availability and acceptance may reduce implementability.	$17,000,000	Eliminated

Table 3.1 (Continued)
Screening of Alternatives for Soil Remediation at the K-Area Bingham Pump Outage Pit, Savannah River Site, South Carolina

General Response/Alternative	Effectiveness	Implementability	Budgetary Cost	Status
11. Excavate soil and debris, solidify/ stabilize soil, backfill treated soil and debris, and soil cover	Residual soil and debris contamination would remain at site. Soil contamination levels are not considered significant. Treatment of soils would reduce mobility of contaminants. Soil cover would provide additional protection for soil exposure pathways and would provide some protection from contaminated debris. Excavation may produce worker exposures.	This alternative is technically and administratively implementable.	$3,400,000	Retained
OFF-UNIT DISPOSAL				
12. Excavation of debris and soil, disposal in E-Area Vaults or Soil Consolidation Facility, if applicable	Removal of soil and debris would eliminate human and ecological exposure pathways. Excavation may produce worker exposures.	This alternative is technically and administratively implementable.	$16,000,000[2]	Retained
13. Excavation of debris and soil, off-site disposal at Envirocare	Removal of debris and soils will eliminate human and ecological exposure pathways. Excavation may produce worker exposures.	Disposal at qualified landfills is an acceptable alternative. This alternative is technically and administratively implementable. SDCF disposal option is being developed/ evaluated in a separate alternatives study.	$21,000,000	Eliminated

[1] - Costs provided are preliminary estimates and should be considered comparative only. Costs are based on K-Area dimensions.

[2] - These costs are based on disposal in E-Area Vaults. The SDCF study will determine approximate costs for SDCF disposal option.

Note: Debris volume = 7,900 cubic yards. Soil volume = 5,250 cubic yards. Soil cover Area = 28,920 square feet (69 ft x 410 ft)

Table 3.2
Screening of Alternatives for Groundwater Remediation at the K-Area Bingham Pump Outage Pit, Savannah River Site, South Carolina

General Response/Alternative	Effectiveness	Implementability	Budgetary Cost[1]	Status
NO REMEDIAL ACTION				
1. No Remedial action	Contamination would be reduced only through natural attenuation. Concentrations detected for contaminants with risks exceeding 1E-4 are suspect.	This alternative is technically and administratively implementable.	$0	Retained
INSTITUTIONAL CONTROLS				
2. Long-term monitoring	Provides protection by detecting changes in groundwater conditions.	Groundwater monitoring is implementable. This alternative is technically and administratively implementable.	$14,000/ sampling round[a]	Eliminated
3. ACL mixing zone	Contamination would be reduced only through natural attenuation. Concentrations detected for contaminants with risks exceeding 1E-4 are suspect. Action levels would be established and corrective action taken if the action levels are exceeded.	The site is currently the property of the Savannah River site. This alternative is technically and administratively implementable.	$290,000[b]	Eliminated
4. Access and deed restrictions	Provides protection for current and future exposure for all groundwater pathways. The BPOPs are located in established industrial zone areas.	This alternative is technically and administratively implementable. However, the state owns the groundwater, which may impact the potential for the use of controls on the groundwater.	$330,000[c]	Eliminated

Table 3.2 (Continued)
Screening of Alternatives for Groundwater Remediation at the K-Area Bingham Pump Outage Pit, Savannah River Site, South Carolina

General Response/Alternative	Effectiveness	Implementability	Budgetary Cost	Status
CONTAINMENT				
5. Soil cover	Installation of a soil cover would be effective for reducing the source of groundwater contamination from the site.	Soil covers are an established technology. This alternative is technically and administratively implementable.	$20 - $25/ Sq Ft plus $280,000 5-year reporting	Eliminated
6. Soil cover and slurry wall	In addition to reduction in source contamination, the exposure to groundwater would be limited through reduced contaminant mobility. A shallow continuous confining unit is necessary for slurry wall effectiveness	Slurry walls are an established technology. This alternative is technically and administratively implementable..	$20 - $25/ Sq Ft for soil cover plus $1000 - $1750/ linear ft for slurry wall plus $280,000 5-year reporting	Eliminated
TREATMENT				
7. Pump groundwater and treat by reverse osmosis	Reverse osmosis has been shown to be potentially effective for remediation of the groundwater contaminants identified for the site.	Reverse osmosis is an established treatment technology. This alternative is technically and administratively implementable.	$50,000 Site Prep plus $2,500,000 plus $0.005/ gallon plus $280,000 5-year reporting	Eliminated
8. Pump groundwater and treat by ion exchange	Ion exchange has been shown to be potentially effective for remediation of the groundwater contaminants identified for the site.	Ion exchange is an established treatment technology. This alternative is technically and administratively implementable.	$50,000 Site Prep plus $250,000 plus $0.05/ gallon plus $280,000 5-year reporting	Eliminated
9. Pump groundwater and treat by precipitation	Precipitation has been shown to be potentially effective for remediation of the groundwater contaminants identified for the site.	Precipitation is an established treatment technology. This alternative is technically and administratively implementable.	$50,000 Site Prep plus $2,000 plus $0.40/ gallon plus $280,000 5-year reporting	Eliminated

[1] - Costs provided are preliminary estimates and should be considered comparative only.
[a] - Assumes 6 wells sampled for metals, radionuclides, and semivolatiles. Includes field work, analytical and validation.
[b] - Assumes 160 hrs x $60/ hr plus 5 year reporting.
[c] - Includes Site maintenace and 5 year reporting

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SECTION 4
DETAILED ANALYSIS OF REMEDIAL ALTERNATIVES

In this section, the remedial alternatives that were selected in Section 3 are further developed and are evaluated against EPA's nine criteria and against one another.

4.1 REMEDIAL GOAL OPTIONS

Remedial goal options (RGOs) were developed in the RI/BRA. The RGOs for soil and groundwater are discussed below.

4.1.1 Groundwater Remedial Goal Options

Constituents of concern are defined as those constituents that result in a cancer risk above $1x10^{-6}$ or a noncancer HI above 1.0 for a given exposure pathway. For nonradiological constituents and radionuclides detected in site samples, cancer risks exceed $1.0x10^{-6}$ and HIs exceed 1.0 for both hypothetical residents and workers exposed to sampled groundwater. The constituents that contribute to these risks and hazards are considered COCs. Remedial goal options, however, are only derived for those constituents detected in groundwater that exceed appropriate MCL values.

Remedial goal options were not derived for I-129 and arsenic in groundwater. Although these constituents were detected in the initial groundwater sampling round (samples bailed from temporary piezometers), they were not detected in the confirmatory sampling of permanent monitoring wells that were sampled using methodology designed to eliminate excess silt in the samples. Consequently, they are not considered to be COCs in groundwater at the KBPOP. Based on these conclusions of the RI and BRA, remedial options for groundwater will not be considered in this FS.

4.1.2 Soil Remedial Goal Options

External exposure of hypothetical receptors to Cs-137 results in cancer risks of $1x10^{-5}$ (residents) and $3x10^{-6}$ (workers), which exceed a cancer risk of $1.0x10^{-6}$. Cs-137 in soil is likely ubiquitous at the K-Area due to global radioactive fallout and is believed not to be a risk driver. However a RGO value is derived.

The RGOs calculated for Cs-137 (from RI/BRA Report, Rev. 1.2) are:

	Target Cancer Risk		
Receptor	**1.00E-04**	**1.00E-05**	**1.00E-06**
Future Worker (pCi/g)	1.06E+01	1.06E+00	1.06E-01
Future Resident (pCi/g)	2.08E+00	2.08E-01	2.08E-02

In addition to any soil remediation goals, the debris is also considered in the detailed analysis to prevent future exposure/contact to the debris since the debris contains low level radioactive material to which future contact/exposure should be minimized.

4.2 INDIVIDUAL ANALYSIS OF SOIL/ DEBRIS ALTERNATIVES

The alternatives that remained after screening in Section 3 were renumbered as follows:

Alternative 1 (Formerly No. 1)	No Remedial Action
Alternative 2 (Formerly No. 2)	Access and Deed Restrictions/Notifications
Alternative 3 (Formerly No. 3)	Soil cover
Alternative 4 (Formerly No. 6)	In-Situ Solidification of soil & debris, soil cover
Alternative 5 (Formerly No. 11)	Excavate soil and debris, solidify/stabilize soil, backfill treated soil and debris, construct soil cover
Alternative 6 (Formerly No. 12)	Excavation of Debris and Soil, Disposal in E-Area Vaults or Soil/Debris Consolidation Facility (SDCF), if applicable.

In this section, these six alternatives will be screened on the basis of USEPA's nine criteria for detailed assessment (EPA 1988). These criteria are shown on Table 4.1.

4.2.1 Alternative No. 1: No Remedial Action

4.2.1.1 Description

No remedial actions would be conducted under this alternative, and no limitations would be placed on future uses of the site. All contaminated soil and debris is within the site boundaries. The site is within the SRS facility and is not accessible to the public. The debris is covered by four feet of fill, currently preventing direct contact.

4.2.1.2 Assessment

Overall Protection of Human Health and the Environment

Based upon a review of the six criteria evaluated below, this alternative is shown to provide adequate protection of human health and the environment in the near future. Implementation of this alternative would pose no increase in risks.

Long-term protection of human health and the environment may not be achieved because no physical controls would exist to prevent erosion of the cover and subsequent exposure to debris. Also, no institutional controls would exist to prevent the hypothetical future-use scenario of site development for residential use.

Compliance with ARARs

No Federal or State chemical-, location-, or action-specific ARARs have been identified for this alternative.

Long-term Effectiveness and Permanence

The residual risk remaining under this alternative is less than the EPA's acceptable upper limits.

This alternative provides no assurances that current conditions will remain in the future. With no institutional or physical controls, a hypothetical future scenario has been identified in which the site could be developed for residential use. Under this hypothetical scenario, the debris and contaminated soil would be brought to the surface. Both child and adult receptors would be exposed to contaminated material through ingestion, dermal contact, inhalation of contaminated particulates, and inhalation of organic vapors. The magnitude of potential risks from these pathways under the hypothetical future scenario was calculated. Under this alternative, the residual risk would not exceed EPA's acceptable limits under the hypothetical future use scenario.

Also, this no-action alternative would provide no permanence. Without periodic inspections and repairs, the existing cover could erode, allowing human and environmental contact with the underlying debris.

Erosion of the cover could also lead to increased leaching of contaminants from the debris as surface water infiltrates through the fill.

Reduction of Toxicity, Mobility, and Volume

Treatment would not be employed under this alternative. There would be no reduction in the toxicity, mobility, or volume of toxic substances or of contaminated media.

Short-term Effectiveness

This alternative offers short-term effectiveness in meeting RAOs because human health risks and environmental threats are acceptable under current conditions. The existing cover is vegetated, and excessive erosion of the cover has not been observed. Excessive erosion over the next several years is not anticipated. Because no remedial actions would be implemented, short-term threats to workers, the local community, or the environment would not be posed by this alternative.

Implementability

There are no technical or administrative constraints to the implementation of this alternative because no remedial actions are required.

Cost

As shown on Table 4.2, this alternative has no capital costs. The present worth of this alternative is $280,000. This cost is the cost required for five year reporting for thirty years.

4.2.2 Alternative No. 2: Access and Deed Restrictions

4.2.2.1 Description

Under this alternative, the site would remain undisturbed. A fence would be built around the perimeter of the BPOP to prevent SRS workers from entering the area. Periodic inspections would be conducted and maintenance would be performed to help ensure that the cover remains intact. Maintenance, as needed, would consist of semi-annual mowing and repair of damaged fencing. Minor drainage modifications may be conducted as needed to prevent ponding and promote surface water runoff.

Limitations would be placed on future uses of the site. A survey plat indicating the location of the waste disposal area with respect to permanently surveyed benchmarks would be prepared and filed with the local zoning authority. The plat would contain a note, prominently displayed, which states the owner's obligation to restrict disturbance of the waste.

4.2.2.2 Assessment

Overall Protection of Human Health and the Environment

Alternative No. 2 meets all of the RAOs for soil through limitations on site development, by preventing inadvertent site access, and by preventing potential long-term direct contact with contaminated materials.

Based upon a review of the six criteria evaluated below, this alternative is shown to provide adequate protection of human health and the environment in the near future.

Long-term protection of human health and the environment would be achieved through deed restrictions and maintenance of the cover and fence.

Implementation of this alternative would pose no increase in risks to onsite workers, the local community, or the environment because the cover would not be disturbed and contaminated media would not be exposed during implementation of the remedy.

Compliance with ARARs

No Federal or State chemical-, location-, or action-specific ARARs have been identified for this alternative.

Long-term Effectiveness and Permanence

The residual risk under this alternative is the same as that determined in the BRA. The carcinogenic risks for current exposures are below the EPA's acceptable limits. The noncancer hazard index is below the EPA's maximum acceptable hazard index. Therefore, under current conditions, the risks presented by the site would be within the EPA's acceptable limits.

The BRA also examined hypothetical future exposure scenarios. The noncancer hazard indices calculated for the future scenarios were each less than the EPA's maximum acceptable limit.

This alternative would further reduce the future risks presented by the site by limiting or preventing future exposure pathways.

Reduction of Toxicity, Mobility, and Volume

Treatment would not be employed under this alternative. All contaminated media would remain onsite and there would be no reduction in the toxicity, mobility, or volume of toxic substances or of contaminated media.

Short-term Effectiveness

No threats to workers, the local community, or the environment would be posed during implementation of this alternative because the cover would not be disturbed and contaminated materials would not be exposed.

Remedial action objectives would be immediately met because human exposure is currently prevented, and would continue to be prevented during and after implementation of the remedy.

Implementability

There are no technical or administrative constraints to the implementation of this alternative. Inspections of the cover, vegetation, and perimeter fence could be performed by personnel from SRS, or a contractor could be hired to conduct periodic inspections. Likewise, SRS personnel could perform routine maintenance, or local firms could be contracted to perform maintenance.

Placement of deed restrictions or notices would require legal assistance to record the restrictions and notices on the deed. However, no administrative limitations are known.

Cost

As shown in Table 4.2, the capital costs to implement Alternative 2 would be \$21,000 to \$31,000. The O&M costs associated with this alternative are estimated at \$1,600 per year in 1996 dollars. The O&M costs include periodic repairs to the site and maintenance of the fence.

The estimated present worth for this alternative, including capital costs and 30 years of O&M and reporting, ranges from \$320,000 to \$330,000. Detailed cost estimate breakdowns are contained in Appendix A.

4.2.3 Alternative No. 3: Soil Cover

4.2.3.1 Description

Under this alternative, the site would be covered by a low-permeability soil cover. This alternative involves grading and clearing the site as necessary, and constructing a soil cover with a minimum thickness of three feet and a nominal in-place saturated hydraulic conductivity of 1×10^{-5} cm/s or less. The soil cover would have an upper surface with a slope of three to five percent to promote surface water runoff and to minimize surface erosion. A topsoil layer having a minimum thickness of three to six inches would be placed on top of the soil cover. The topsoil would be seeded with native grasses to increase evapotranspiration. The topsoil layer would also protect the soil cover from damage due to erosion, frost, and burrowing animals.

The soil cover would be placed over an area of approximately 2,600 m^2 (28,000 ft^2). The soil cover dimensions would be approximately 69 feet by 410 feet, which extends five feet beyond each side of the KBPOP.

4.2.3.2 Assessment

Overall Protection of Human Health and the Environment

Alternative No. 3 meets all of the RAOs for soil through elimination of exposure pathways to contaminated soils. Based upon a review of the six criteria evaluated below, this alternative is shown to provide adequate protection of human health and the environment in the near and long-term future. The contaminated material would be isolated by the soil cover. In addition, contaminant mobility would be minimized by reductions in infiltration and erosion.

Compliance with ARARs

No chemical-specific or location-specific ARARs have been identified for this alternative. Portions of the following regulations were identified as potential action-specific ARARs:

- 40 CFR 264.111 - Closure performance standard; and
- 40 CFR 264.114 - Disposal or decontamination of equipment, structures, and soils.

Implementation of this alternative would result in compliance with all of the potential ARARs.

The alternative meets the requirements of 40 CFR 264.111, which states that closure must be conducted in a manner that minimizes the need for further maintenance and controls, minimizes, or eliminates escape of hazardous waste. By meeting the minimum design requirements for a low-permeability soil cover, maintenance will be minimized.

The alternative would meet the requirements of 40 CFR 264.114, which requires that contaminated equipment, structures, and soils be properly disposed of or decontaminated. Any equipment that contacts hazardous materials would be decontaminated. No contaminated structures or soils are expected to be encountered during implementation of this alternative.

Long-term Effectiveness and Permanence

Risk to human health or the environment would be eliminated following implementation of this remedy because the soil cover would prevent human and environmental receptors from contacting contaminated media.

The soil cover would offer adequate and reliable protection. Soil covers are commonly constructed for similar uses and have been found effective and reliable. Periodic maintenance would assure the soil cover's long-term integrity.

Reduction of Toxicity, Mobility, and Volume

Treatment would not be employed under this alternative, and contaminated media would remain onsite. Implementation of Alternative No. 3 would not reduce the toxicity or volume of contaminated soil onsite. This alternative will reduce the mobility of the contaminants by reducing contact of infiltrating surface water with contaminated soil/debris.

Short-term Effectiveness

No impacts to the surrounding community are anticipated during the implementation of this remedy. Soil cover construction will not result in exposure to contaminated media.

Work onsite would be conducted in accordance with Occupational Safety and Health Administration (OSHA) regulations for work on hazardous waste sites, as well as general OSHA work safety requirements. Workers are unlikely to be exposed to contaminated media because construction of the soil cover does not require excavation of contaminated materials. Radiation levels would be monitored during onsite activities.

Remedial action objectives would be immediately met. Currently, no human or environmental exposures are occurring, so the RAOs are currently met and would continue to be met during and after implementation of the remedy. Alternative No. 3 is expected to require approximately two months of onsite activity to complete.

Implementability

No implementation restrictions have been identified for this remedy. Soil cover design and construction utilize proven technologies and no site limitations have been identified that would preclude their use at this site. The equipment and materials are readily available and are reliable. Remediation contractors experienced in the implementation of this technology at hazardous waste sites are available.

Cost

As shown in Table 4.2, the capital costs to implement Alternative 3 would be $280,000 to $320,000. The O&M costs associated with this alternative are estimated at $2,600 per year in 1996 dollars.

The estimated present worth for this alternative, including capital costs and 30 years of O&M costs, ranges from $600,000 to $640,000. Detailed cost estimate breakdowns are contained in Appendix A.

4.2.4 Alternative No. 4: In-situ Solidification of Soil and Debris; Soil Cover

4.2.4.1 Description

Under this alternative, a concrete-based agent would be injected into the site and mixed with the soil and debris to form a solidified mass. The concrete material is injected into the ground in columns. The columns are placed in an overlapping pattern to provide treatment over the entire target area. The solidification process would produce a monolithic structure which would eliminate or reduce the mobility of the contaminants. The treated site would then be covered with a soil cover as described under alternative 3.

Preliminary testing of the site would be required to determine the appropriate ratio of water to cement required for the site. Testing to determine any special techniques needed to effectively treat the debris material would also be required.

4.2.4.2 Assessment

Overall Protection of Human Health and the Environment

Alternative No. 4 meets all of the RAOs through elimination of exposure pathways and reductions in contaminant mobility. Based upon a review of the six criteria evaluated below, this alternative is shown to provide adequate protection of human health and the environment in the near and long-term future. The contaminated material would be isolated by the soil cover. In addition, contaminant mobility would be minimized by solidification and reductions in infiltration and erosion.

Compliance with ARARs

No chemical-specific or location-specific ARARs have been identified for this alternative. Portions of the following regulations were identified as potential action-specific ARARs:

- 40 CFR 264.111 - Closure performance standard; and
- 40 CFR 264.114 - Disposal or decontamination of equipment, structures, and soils.

Implementation of this alternative would result in compliance with all of the potential ARARs.

The alternative meets the requirements of 40 CFR 264.111, which states that closure must be conducted in a manner that minimizes the need for further maintenance and controls, minimizes, or eliminates escape of hazardous waste. By meeting the minimum design requirements for a low-permeability soil cover, maintenance will be minimized.

The alternative would meet the requirements of 40 CFR 264.114, which requires that contaminated equipment, structures, and soils be properly disposed of or decontaminated. Any equipment that contacts hazardous materials would be decontaminated.

Long-term Effectiveness and Permanence

Treatment would not completely eliminate the risk to human health or the environment because solidification would only immobilize, not remove, contaminants. Contaminants would remain in the soil and debris, posing a potential threat from ingestion or direct contact.

The potential threat to human health and the environment would be reduced following implementation of this alternative because the installation of the soil cover

over the solidified material would prevent human and environmental receptors from contacting the contaminated media.

The soil cover would reduce the amount of surface water infiltrating the site. Solidification would reduce or eliminate migration of contaminants from soil or debris to infiltrating surface water.

Solidification is an established technology that can be used for immobilization of inorganic contaminants. Testing during implementation would assure that the technology would be effective.

Reduction of Toxicity, Mobility, and Volume

Solidification would provide effective reduction or elimination of the mobility of site contaminants. The total volume of contaminated material would be increased by up to 100 percent of the original volume. The total mass of inorganic contaminants would remain unchanged. This alternative was considered, however, because the soil cover would further reduce contaminant migration by limiting surface water infiltration.

Short-term Effectiveness

Implementation of this alternative would produce only limited exposures of workers to contaminated material. Because excavation is not required, exposure to contaminated materials and/or fugitive dust would be minimal. Limited exposures would be required to perform process confirmation testing. Personnel protective equipment would be utilized during all activities to further protect onsite workers. Radiation levels would also be monitored during onsite activities.

The RAOs would not be achieved through treatment, but would be achieved once the soil cover is in place. This alternative is not expected to require more than 3 months to implement.

Implementability

Treatment and soil cover construction are both implementable using readily available materials and equipment. Implementation of treatment could be hindered by the presence of debris. The debris could cause incomplete treatment of contaminated materials, and special grouting procedures may need to be developed.

Soil cover design and construction utilize proven technologies and no site limitations have been identified that would preclude their use at this site. The equipment and materials are readily available and are reliable. Remediation contractors experienced in the implementation of these technologies at hazardous waste sites are available.

<u>Cost</u>

As shown in Table 4.2, the capital costs to implement Alternative 4 would be $1,800,000 to $2,600,000. The O&M costs associated with this alternative are estimated at $2,600 per year in 1996 dollars.

The estimated present worth for this alternative, including capital costs and 30 years of O&M costs, ranges from $2,100,000 to $2,900,000. Detailed cost estimate breakdowns are contained in Appendix A.

4.2.5 Alternative No. 5: Excavate Soil and Debris, Solidification of Soil, Backfill Treated Soil and Debris; Soil Cover

4.2.5.1 Description

Under this alternative the identified soil and debris would be excavated by backhoe or similar means. Excavation would extend to four feet below the lower boundary of the debris. The excavated material would then be staged at the site. Impermeable tarps would be placed on the ground prior to placement of the excavated material and similar tarps would also be placed over individual piles to avoid producing airborne particulates and contaminated runoff. Other containment measures would be implemented as needed.

Debris would be separated from the soil using mechanical means such as screens and electromagnets. The excavated soil would be treated by solidification with Portland cement. The material would be mixed with the cement to form solid blocks that would eliminate or reduce the mobility of the contaminants. Preliminary testing would be required to determine an appropriate ratio of cement to soil and/or debris.

The debris and treated soil would then be backfilled into the excavation. A soil cover, as described in Section 4.2.3, would be constructed over the site.

4.2.5.2 Assessment

<u>Overall Protection of Human Health and the Environment</u>

Alternative 5 meets all of the RAOs through elimination of exposure pathways and reductions in contaminant mobility. Based upon a review of the six criteria evaluated below, this alternative is shown to provide adequate protection of human health and the environment in the near and long-term future.

Excavation will present limited short-term potential exposures to workers. Following completion of remedial activities, the contaminated material would be isolated by the soil cover. In addition, the mobility of contaminants in the soil would be minimized by solidification and by reductions in infiltration and erosion.

Compliance with ARARs

No chemical-specific or location-specific ARARs have been identified for this remedial alternative. Portions of the following regulations were identified as potential action-specific ARARs:

- 40 CFR 264.111 - Closure performance standard;
- 40 CFR 264.114 - Disposal or decontamination of equipment, structures, and soils;
- 40 CFR 264.251 - Waste pile design and operating requirements;
- 40 CFR 264.258(a) - Requirements for closure of waste piles;

Implementation of this alternative would result in compliance with all of the potential ARARs.

The alternative meets the requirements of 40 CFR 264.111, which states that closure must be conducted in a manner that minimizes the need for further maintenance and controls, minimizes, or eliminates escape of hazardous waste. By applying a 24-inch thick vegetated topsoil cover, site maintenance will be minimized. The release of hazardous substances would be minimized because the stabilized matrix will immobilize the inorganic contaminants and prevent leaching of contaminants into groundwater.

The alternative would meet the requirements of 40 CFR 264.114, which requires that contaminated equipment, structures, and soils be properly disposed of or decontaminated. Any equipment that contacts hazardous materials would be decontaminated. Any hazardous materials generated during the implementation of this alternative will be properly disposed of.

Waste piles would be constructed and operated in a manner that complies with 40 CFR 264.251, which specifies waste pile design and operating requirements. The waste piles would be closed in compliance with 40 CFR 264.258(a), which provides requirements for the closure of waste piles.

Long-term Effectiveness and Permanence

Treatment would not completely eliminate the risk to human health or the environment because solidification would only immobilize, not remove, inorganic contaminants. Contaminants would remain in the soil and debris.

The potential threat to human health and the environment would be reduced following implementation of this alternative because the installation of the soil cover over the debris and solidified material would prevent human and environmental receptors from contacting the contaminated media.

The soil cover would reduce the amount of surface water infiltrating the site. Solidification would reduce or eliminate migration of contaminants from soil or debris to infiltrating surface water.

Solidification is an established technology that can be used for immobilization of inorganic contaminants. Testing during implementation would assure that the technology would be effective.

Reduction of Toxicity, Mobility, and Volume

Solidification would provide effective reduction or elimination of the mobility of site contaminants. The total volume of contaminated soil would be increased by up to 100 percent of the original volume. The total mass of inorganic contaminants would remain unchanged. This alternative was considered, however, because the soil cover would further reduce migration by limiting surface water infiltration.

Short-term Effectiveness

Excavation of soil and debris for treatment would result in fugitive dust being released to the atmosphere, potentially exposing onsite workers. No residents are believed to live close enough to the site to be exposed to any potential threat from fugitive dust.

Air monitoring would be conducted during excavation and treatment activities to assure that unacceptable exposure levels for workers do not occur. Personnel protective equipment would be utilized during all activities to further protect onsite workers. Radiation levels would also be monitored during onsite activities.

The RAOs would not be achieved through treatment, but would be achieved once the soil cover is in place. This alternative is not expected to require more than 3 months to implement.

Implementability

Treatment and soil cover construction are both implementable using readily available materials and equipment. No implementation restrictions have been identified for this remedy. Soil cover design and construction utilize proven technologies and no site limitations have been identified that would preclude their use at this site. The equipment and materials are readily available and are reliable. Remediation contractors experienced in the implementation of these technologies at hazardous waste sites are available.

<u>Cost</u>

As shown in Table 4.2, the capital costs to implement Alternative 5 would be $2,000,000 to $3,300,000. The O&M costs associated with this alternative are estimated at $2,600 per year in 1996 dollars.

The estimated present worth for this alternative, including capital costs and 30 years of O&M costs, ranges from $2,300,000 to $3,600,000. Detailed cost estimate breakdowns are contained in Appendix A.

4.2.6 Alternative No. 6: Excavate Debris and Soil; Dispose at E-Area Vaults or Soil/Debris Consolidation Facility, if applicable

4.2.6.1 Description

Alternative No. 6 would require excavation by backhoe or similar means and removal of an estimated 13,150 cubic yards of soil and debris. Excavation would extend to four feet below the lower boundary of the debris. The excavated material would be hauled from the site and disposed at either the E-Area Vaults or the Soil/Debris Consolidation Facility.

The excavation would be backfilled with soil and seeded.

4.2.6.2 Assessment

<u>Overall Protection of Human Health and the Environment</u>

Alternative 6 provides protection of human health and the environment by removing the contamination from the site. Alternative 6 meets all of the RAOs through complete source removal, which eliminates the potential for long-term direct contact with contaminated soil or debris. Excavation will present limited short-term exposures to workers.

<u>Compliance with ARARs</u>

No chemical-specific or location-specific ARARs have been identified for this remedial alternative. Portions of the following regulations were identified as potential action-specific ARARs:

- 40 CFR 264.111 - Closure performance standard;
- 40 CFR 264.114 - Disposal or decontamination of equipment, structures, and soils;
- 49 CFR Part 107 - Requirements for transportation of hazardous waste.

Implementation of this alternative would result in compliance with all of the potential ARARs.

The alternative meets the requirements of 40 CFR 264.111, which states that closure must be conducted in a manner that minimizes the need for further maintenance and controls, minimizes, or eliminates escape of hazardous waste. Removal of the contaminated soil and debris will eliminate the contaminant source from the site and therefore meet the criteria.

The alternative would meet the requirements of 40 CFR 264.114, which requires that contaminated equipment, structures, and soils be properly disposed of or decontaminated. Any equipment that contacts hazardous materials would be decontaminated. Any hazardous materials generated during the implementation of this alternative will be properly disposed of.

Transportation of hazardous waste would be conducted in compliance with the requirements for transportation of hazardous waste as specified in 49 CFR Part 107.

Long-term Effectiveness and Permanence

This alternative provides long-term and reliable effectiveness because all contaminated material is removed from the site. No soil threat would remain at the site after the remediation is complete.

Reduction of Toxicity, Mobility, and Volume

Implementation of Alternative 6 will permanently reduce the concentrations of contaminants present at the site to residual levels below RAOs. However, contaminants and the threat of exposure to the contaminants would be transferred to another site.

Short-term Effectiveness

Excavation of soil and debris would result in fugitive dust being released to the atmosphere, potentially exposing onsite workers. No residents are believed to live close enough to the KBPOP to be exposed to any potential threat from fugitive dust.

Air monitoring would be conducted during excavation activities to assure that unacceptable exposure levels for workers do not occur. Personnel protective equipment would be utilized during all activities to further protect onsite workers. Radiation levels would also be monitored during onsite activities.

The RAOs would be achieved on completion of the excavation and transportation of the contaminated materials. This alternative is not expected to require more than 2 months to implement.

Implementability

Excavation and transport of contaminated soil and debris can be conducted using standard equipment. Contractors for hazardous waste excavation and transport are readily available.

Implementation of this alternative is dependent upon available space at either the E-Area vaults or the consolidation facility and the materials meeting appropriate disposal criteria for these areas.

Cost

As shown in Table 4.2, the capital costs to implement Alternative 6 would be $16,000,000 to $17,000,000. This alternative does not have any O&M costs associated with it. Detailed cost estimate breakdowns are contained in Appendix A.

4.3 SOIL/ DEBRIS COMPARATIVE ANALYSIS

A summary of the comparative analysis is presented as Table 4.3, found at the end of this section.

4.3.1 Overall Protection of Human Health and the Environment

All alternatives provide immediate protection because the debris is covered and no short-term health concerns were identified. Alternative 1 provides the least long term protection because erosion or development could increase exposure. Alternatives 4 and 5 provide the most protection for all alternatives which leave the contaminated materials in place because exposure pathways are limited through treatment. Alternative 6 provides the greatest protection of all because the contaminated material is removed from the site. Alternatives 2 and 3 each offer improvements in protection through reduced exposure potential.

4.3.2 Compliance With ARARs

All alternatives comply with all identified ARARs.

4.3.3 Long-term Effectiveness and Permanence

Alternative 1 provides the least long-term effectiveness because the threat of exposure may increase as the cover becomes eroded. The residual risk present at the site is the same for Alternatives 1 through 5 because contaminants will remain at the site. However, Alternatives 4 and 5 provide the greatest degree of control over potential exposures. Alternatives 2 and 3 also provide added controls for limiting future exposures. Alternative 6 provides the greatest protection and controls because the contaminated material is removed from the site.

All alternatives except Alternative 6 require 5-year review because contaminated material would be left on site.

4.3.4 Reduction of Toxicity, Mobility, or Volume Through Treatment

None of the alternatives reduce the toxicity or volume of contaminated material in existence. Alternative 6, however, does reduce the volume of contaminated material at the KBPOP through removal to another location. Alternative 3 provides mobility reduction through the placement of a soil cover. Alternatives 4 and 5 each offer greater reductions in mobility by implementing solidification in addition to the placement of a soil cover. However, these alternatives each will increase the volume of contaminated material by up to 100%. Alternatives 1 and 2 provide no reductions in toxicity, mobility, or volume.

4.3.5 Short-term Effectiveness

None of the alternatives present any threats to surrounding communities. Alternatives 1 and 2 do not require intrusive on-site work, so no worker exposure concerns are presented by these alternatives. Alternative 3 is not expected to present any significant worker exposure either, as soil cover construction will not generate significant contact with the contaminated material.

Alternatives 4, 5, and 6 each involve contact with the contaminated material, and therefore present some degree of worker risk. Because Alternative 4 provides in-situ treatment, contact would be minimal and the worker risk would be less than for Alternatives 5 and 6. Alternatives 5 and 6 each require excavation and therefore present the highest levels of worker exposure. Adequate personal protection could be provided for workers under each alternative.

None of the alternatives would require significant amounts of time to complete. A maximum of 3 months is estimated for completion of on-site activities.

4.3.6 Implementability

No major implementation problems were identified for Alternatives 1, 2, 3, and 5. Alternatives 4 and 5 may present minor difficulties in selection of qualified contractors. Alternative 4 may also present potential implementation problems because of requirements for grouting through debris. Alternative 6 presents potential implementation problems because the availability of space at the disposal facilities may hinder disposal. Evaluation of regulatory and acceptance criteria would also be required.

4.3.7 Cost

Cost comparisons are shown in Table 4.2.

Table 4.1 Criteria for Detailed Evaluation of Remedial Alternatives

OVERALL PROTECTION OF HUMAN HEALTH AND THE ENVIRONMENT

- How Alternative Provides Human Health and Environmental Protection

COMPLIANCE WITH ARARS

- Compliance With Chemical-Specific ARARs
- Compliance With Action-Specific ARARs
- Compliance With Location-Specific ARARs
- Compliance With Other Criteria, Advisories, and Guidances

LONG-TERM EFFECTIVENESS AND PERMANENCE

- Magnitude of Residual Risk
- Adequacy and Reliability of Controls

REDUCTION OF TOXICITY, MOBILITY, AND VOLUME THROUGH TREATMENT

- Treatment Pocess Used and Materials Treated
- Amount of Hazardous Materials Destroyed or Treated
- Degreee of Expected Reduction in Toxicity, Mobility, and Volume
- Degree to Which Treatment is Irreversible
- Type and Quantity of Residuals Remaining After Treatment

SHORT-TERM EFFECTIVENESS

- Protection of Community During Remedial Actions
- Protection of Workers During Remedial Actions
- Environmental Impacts
- Time Until Remedial Action Objectives are Achieved

IMPLEMENTABILITY

- Ability to Construct and Operate the Technology
- Reliability of the Technology
- Ease of Undertaking Additoinal Remedial Actions, if Necessary
- Ability to Monitori Effectiveness of Remedy
- Ability to Obtain Approvals from Other Agencies
- Coordination With Other Agencies
- Availability of Offsite Treatment, Storage, and Disposal Facilities and Capacity
- Availability of Necessary Equipment and Specialists
- Availability of Prospective Technologies

COST

- Capital Costs
- Operating and Maintenance Costs
- Present Worth Cost

STATE ACCEPTANCE[1]

COMMUNITY ACCEPTANCE[1]

[1]These criteria are assessed following comment on the RI/FS report and the proposed plan.

Source: From EPA 1988.

TABLE 4.2
ESTIMATED CAPITAL AND PRESENT WORTH COSTS OF REMEDIAL ALTERNATIVES FOR SOIL AND DEBRIS
Savannah River Site
K-Area BPOP

Alternative		Capital Cost ($ x 1000)		Present Worth ($ x 1000)	
		Low	High	Low	High
1	No action	$0	$0	$280	$280
2	Access and deed restrictions	$21	$31	$320	$330
3	Soil cover	$280	$320	$600	$640
4	In-situ solidification of soil and debris; soil cover	$1,800	$2,600	$2,100	$2,900
5	Excavate soil and debris; solidification of soil; backfill treated soil and debris; soil cover	$2,000	$3,300	$2,300	$3,600
6	Excavate soil and debris; dispose at E-Area vaults or consolidation facility, if applicable	$16,000	$17,000	$16,000	$17,000

All costs are in thousands of dollars.

All Alternatives except Alternative 6 (off site disposal) include costs for Agency Reporting.

Alternative 2 assumes approximately 0.5 acres attended.

Alternative 3 assumes the multilayer soil cover will extend five feet beyond the pit boundaries.

Alternative 4 assumes 13,150 cubic yards of material treated with 50 to 100 percent cement and a multilayer soil cover extending 5 feet beyond the pit boundaries.

Alternative 5 assumes 7,900 cubic yards of debris and 5,250 cubic yards of soil and a multilayer soil cover extending 5 feet beyond the pit boundaries.

Alternative 6 assumes E-Area disposal costs and ten mile round trip for disposal.

TABLE 4.3
COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES FOR SOIL CONTAMINATION
SAVANNAH RIVER SITE K AREA BPOP

Criteria	Alternative No. 1 No Action	Alternative No. 2 Access & Deed Restrictions	Alternative No. 3 Soil cover	Alternative No. 4 In-situ Solidification of soil; backfill treated soil and debris; soil cover	Alternative No. 5 Excavate soil and debris; solidification of soil; backfill treated soil and debris; soil cover	Alternative No. 6 Excavate soil and debris; dispose at E-Area vaults or consolidation facility, if applicable
OVERALL PROTECTIVENESS						
Human Health Protection	Provides same immediate protection as all other alternatives, but affords lower long-term protection due to possibility of cover or site development. Current risks are within EPA's acceptable limits.	Provides immediate protection through access restrictions; provides long-term protection through access and use restrictions.	Provides immediate and long term protection through elimination of exposure pathways.	Same as Alternative 3 except provides additional protection by solidification.	Same as Alternative 4.	Provides protection of human health by removing contaminated material.
Environmental Protection	Lowest degree of protection because cover erosion could result in contaminant exposure.	Greater long-term protection than Alternative 1 because site contact would be minimized.	More than Alternative 2 because soil cover would further reduce contact with contaminated material.	More than Alternative 3 because solidification would further reduce contact with contaminants.	Same as Alternative 4.	Provides protection of environment by removing contaminated material.
COMPLIANCE WITH ARARS						
Chemical-Specific ARARs	Not applicable; none identified.	Not applicable; none identified.	Not applicable; none identified.	Not applicable; none identified.	Not applicable; none identified.	Not applicable; none identified.
Location-Specific ARARs	Not applicable; none identified.	Not applicable; none identified.	Not applicable; none identified.	Not applicable; none identified.	Not applicable; none identified.	Not applicable; none identified.

TABLE 4.3- continued
COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES FOR SOIL CONTAMINATION
SAVANNAH RIVER SITE K AREA BPOP

Criteria	Alternative No. 1 No Action	Alternative No. 2 Access & Deed Restrictions	Alternative No. 3 Soil cover	Alternative No. 4 In-situ Solidification of soil; backfill treated soil and debris; soil cover	Alternative No. 5 Excavate soil and debris; solidification of soil; backfill treated soil and debris; soil cover	Alternative No. 6 Excavate soil and debris; dispose at E-Area vaults or consolidation facility, if applicable
Action-Specific ARARs	None identified.	None identified.	Meets all identified ARARS.	Meets all identified ARARS.	Meets all identified ARARS.	Meets all identified ARARS.
<u>LONG-TERM EFFECTIVENESS AND PERMANENCE</u>						
Magnitude of Residual Risk	Least reduction of all alternatives because no reduction would occur and threat could increase if site is not maintained. Current risk is within EPA's acceptable limits.	Slightly less than Alternative 1 because site would be maintained.	Same as Alternative 2.	Same as Alternative 2.	Same as Alternative 2.	Greatest protection because all contaminated material is removed.
Adequacy and Reliability of Controls	No Controls.	Controls can prevent contact with contaminated media.	More reliable than Alternative 2.	More reliable than Alternative 3.	Same as Alternative 4.	Greatest reliability because all contaminated material is removed.
Need for 5-year Review	All Alternatives except 6 require 5 year review.	All Alternatives except 6 require 5 year review.	All Alternatives except 6 require 5 year review.	All Alternatives except 6 require 5 year review.	All Alternatives except 6 require 5 year review.	No review necessary because no waste would remain onsite.

TABLE 4.3- continued
COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES FOR SOIL CONTAMINATION
SAVANNAH RIVER SITE K AREA BPOP

Criteria	Alternative No. 1 No Action	Alternative No. 2 Access & Deed Restrictions	Alternative No. 3 Soil cover	Alternative No. 4 In-situ Solidification of soil; backfill treated soil and debris; soil cover	Alternative No. 5 Excavate soil and debris; solidification of soil; backfill treated soil and debris; soil cover	Alternative No. 6 Excavate soil and debris; dispose at E-Area vaults or consolidation facility, if applicable
<u>REDUCTION OF TOXICITY, MOBILITY AND VOLUME THROUGH TREATMENT</u>						
Treatment Process Used	None.	None.	None.	Directly treats inorganic contaminants.	Directly treats inorganic contaminants.	None.
Amount Destroyed or Treated	None.	None.	None.	Treats all inorganics within site, but total mass of organics remains the same.	Treats all inorganics within site, but total mass of organics remains the same.	None.
Reduction of Toxicity, Mobility, or Volume	None.	None.	Mobility of contaminants is reduced by soil cover.	Volume of contaminated material would be increased by up to 100% of the original volume, mobility of contaminants would be less than under Alternative 3.	Same as Alternative 4, except debris would not be treated by solidification.	None.
Irreversible Treatment	Not applicable, no treatment.	Not applicable, no treatment.	Not applicable, no treatment.	No further remedies could be undertaken on the treated material.	Same as Alternative 4.	Material would be removed.

TABLE 4.3- continued
COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES FOR SOIL CONTAMINATION
SAVANNAH RIVER SITE K AREA BPOP

Criteria	Alternative No. 1 No Action	Alternative No. 2 Access & Deed Restrictions	Alternative No. 3 Soil cover	Alternative No. 4 In-situ Solidification of soil; backfill treated soil and debris; soil cover	Alternative No. 5 Excavate soil and debris; solidification of soil; backfill treated soil and debris; soil cover	Alternative No. 6 Excavate soil and debris; dispose at E-Area vaults or consolidation facility, if applicable
Type and Quantity of Residuals Remaining after Treatment	Not applicable, no treatment.	Not applicable, no treatment.	Not applicable, no treatment.	Same remaining residuals as Alternatives 1 through 3, but volume would increase and residuals would be solidified.	Same as Alternative 4.	Not applicable, no treatment.
SHORT-TERM EFFECTIVENESS						
Community Protection	No threat to community during implementation.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.	Same as Alternative 1.
Worker Protection	No threat of exposure to workers.	Same as Alternative 1.	Same as Alternative 1.	Greater threat than Alternatives 1, 2 and 3 because treatment would require limited contact with contaminated materials.	Greater threat than Alternative 4 because treatment would require excavation of contaminated material.	Same as Alternative 5.

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TABLE 4.3- continued
COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES FOR SOIL CONTAMINATION
SAVANNAH RIVER SITE K AREA BPOP

Criteria	Alternative No. 1 No Action	Alternative No. 2 Access & Deed Restrictions	Alternative No. 3 Soil cover	Alternative No. 4 In-situ Solidification of soil; backfill treated soil and debris; soil cover	Alternative No. 5 Excavate soil and debris; solidification of soil; backfill treated soil and debris; soil cover	Alternative No. 6 Excavate soil and debris; dispose at E-Area vaults or consolidation facility, if applicable
Environmental Impacts	No environmental threat during implementation.	Same as Alternative 1.	Same as Alternative 1.	Slight environmental threat because of limited contact with contaminated materials.	Greater threat than Alternative 4 because treatment would require excavation of contaminated material.	Same as Alternative 5.
Time Until Action is Complete	Immediate.	Immediate.	Immediately effective, but onsite action would require 1 to 2 months after remedial design and contractor selection.	Immediately effective, but onsite action would require 2 to 3 months after remedial design and contractor selection.	Immediately effective, but onsite action would require 2 to 3 months after remedial design and contractor selection.	Immediately effective, but onsite action would require 2 to 3 months after remedial design and contractor selection.
IMPLEMENTABILITY						
Ability to Construct and Operate	No construction or operation.	Same as Alternative 1.	Simple to construct and maintain.	More difficult than Alternative 3 because special equipment is required for treatment.	Similar to Alternative 4.	Requires regulatory evaluation and comparison to waste acceptance criteria.

TABLE 4.3- continued
COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES FOR SOIL CONTAMINATION
SAVANNAH RIVER SITE K AREA BPOP

Criteria	Alternative No. 1 No Action	Alternative No. 2 Access & Deed Restrictions	Alternative No. 3 Soil cover	Alternative No. 4 In-situ Solidification of soil; backfill treated soil and debris; soil cover	Alternative No. 5 Excavate soil and debris; solidification of soil; backfill treated soil and debris; soil cover	Alternative No. 6 Excavate soil and debris; dispose at E-Area vaults or consolidation facility, if applicable
Ease of Doing More Action if Needed	Additional action easily implemented.	Same as Alternative 1.	Same as Alternative 1.	No further remedies could be undertaken on treated waste.	No further remedies could be undertaken on treated waste.	Contaminated material would be removed from site, so additional remedies would not be necessary.
Ability to Monitor Effectiveness	Alternative includes no monitoring; future exposure could occur in absence of controls.	Frequent inspection of property would provide notice of changes.	Same as Alternative 2.	Same as Alternative 2, except effectiveness of solidification would not be monitored.	Same as Alternative 2, except effectiveness of solidification would not be monitored.	No need to monitor because waste would not remain on site.
Availability of Services and Equipment	No services or equipment needed.	Services are available locally.	Services and equipment are available.	Less than Alternative 3, longer lead time may be needed to secure services and equipment.	Same as Alternative 4.	Same as Alternative 4.
<u>COST</u>						
Capital Cost	$0	$21,000 - $31,000	$290,000 - $330,000	$1,800,000 - $2,600,000	$2,000,000 - $3,300,000	$16,000,000 - $17,000000
First Year Annual O&M Cost	$0	$1,600 - $1,700	$2,600	$2,600	$2,600	$0
Present Worth	$280,000	$320,000 - $330,000	$610,000 - $650,000	$2,100,000 - $2,900,000	$2,300,000 - $3,600,000	$16,000,000 - $17,000,000

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APPENDIX A
COST ESTIMATE DETAILS

O&M and Present Worth Calculations Soil Alternative No. 1
No Action

Activity	Quantity	Unit Rate	Low Estimate	High Estimate
Annual O&M costs				
Present Worth O&M costs			*$0*	*$0*
Interest Rate	0.05			
Number of Years	30			
Present Worth Factor = ((1+i)^n)-1 / i(1+i)^n	15.37			
O&M Present Worth			***$0***	***$0***
Agency Reporting (1/ 5 years) Present Worth			***$278,200***	***$278,200***
Total Capital Costs			***$0***	***$0***
TOTAL ALTERNATIVE #1 COST			**$278,200**	**$278,200**

CAPITAL COST ESTIMATE
SOIL ALTERNATIVE NO. 1

Source of Rates		Cost Component	Quantity Estimate		Unit Rate Low Estimate		Unit Rate High Estimate		Estimated Cost Low	Estimated Cost High
	1.0	**CLAY CAP**								
a	1.1	Mobilization/Demobilization			$25,000		$25,000		$0	$0
b	1.2	Cap Construction (1)(5)	sq ft		$2.22	/sq ft	$2.22	/sq ft	$0	$0
a	1.3	Clay - Borrow and Delivery Cost (2' uniform comp. thickness)(3)(7)	0 cubic yds		$4.00	/cubic yd	$15	/cubic yd	$0	$0
a	1.4	Sand/Soil Layer- Borrow and Delivery Cost (1.5' uniform thickess)(3)	0 cubic yds		$4.00	/cubic yd	$12	/cubic yd	$0	$0
a	1.5	Topsoil Layer- Purchase and Delivery Cost (6" uniform thickness)(3)	0 cubic yds		$6.00	/cubic yd	$15	/cubic yd	$0	$0
a	1.6	Vegetation (Seeding)	0 sq ft		$0.03	/sq ft	$0.05	/sq ft	$0	$0
		Sub-total							*$0*	*$0*
	2.0	**MISCELLANEOUS**								
a	2.1	Cap Construction Soil Testing/Sampling	samples		$50	/sample	$50	/sample	$0	$0
a	2.2	Trailer and Utilities	months		$1,000	/month	$1,000	/month	$0	$0
		Sub-total							*$0*	*$0*
		Total							*$0*	*$0*
		Contingency @ 10%							*$0*	*$0*
		Total Construction Costs							*$0*	*$0*
	3.0	**ENGINEERING COSTS**								
a	3.1	Engineering Management	lump sum	lump sum		lump sum		lump sum	$0	$0
a	3.2	Remedial Design Workplan	hrs	hrs	$80	/hr	$80	/hr	$0	$0
a	3.3	Design Plans/Specs	lump sum	lump sum		lump sum		lump sum	$0	$0
a	3.4	Bidding & Contracting	lump sum	lump sum		lump sum		lump sum	$0	$0
a	3.5	Oversight - 1 Month	lump sum	lump sum		lump sum		lump sum	$0	$0
a	3.6	Surveying	lump sum	lump sum		lump sum		lump sum	$0	$0
a	3.7	Closure documents	hrs	hrs	$80	/hr	$80	/hr	$0	$0
a	3.8	Support Plans (H&S, Permitting,etc)	hrs	hrs	$80	/hr	$80	/hr	$0	$0
a	3.9	Remedial Alternative Workplan	hrs	hrs	$80	/hr	$80	/hr	$0	$0
		Sub-total							$0	$0
		Total Estimated Capital Cost (1.0+2.0+3.0)							**$0**	**$0**

a) Parsons ES Estimate
b) GeoCon Estimate

O&M and Present Worth Calculations
Soil Alternative No. 2
Access and Deed Restrictions

Activity	Quantity	Unit Rate	Low Estimate	High Estimate
Annual O&M costs				
Mowing and Inspection - semiannual	2 per year	$500	**$1,000**	**$1,000**
Repairs - Soil additions/spreading, reseeding, misc)	0.5 acre	$1,000	**$500**	**$500**
Fence Repair/ Maintenance	10 lf	$6-$18	**$60**	**$180**
Present Worth O&M costs			*$1,560*	*$1,680*
Interest Rate	0.05			
Number of Years	30			
Present Worth Factor = ((1+I)^n)-1/ I(1+I)^n	15.37			
O&M Present Worth			***$23,981***	***$23,981***
Agency Reporting (1/ 5 years) Present Worth			***$278,200***	***$278,200***
Total Capital Costs			***$21,360***	***$31,480***
TOTAL ALTERNATIVE #2 COST			**$323,541**	**$333,661**

CAPITAL COST ESTIMATE
SOIL ALTERNATIVE NO. 2
ACCESS AND DEED RESTRICTIONS

Source of Rates	Cost Component		Quantity Estimate				Unit Rate Low Estimate		Unit Rate High Estimate		Estimated Cost Low	Estimated Cost High
	1.0	**Access Restrictions**										
a	1.1	Fence Construction	1000 linear feet				$12.60	/lf	$17.80	/lf	$12,600	$17,800
		Sub-total									*$12,600*	*$17,800*
	2.0	**Deed Restrictions**										
b	2.1	Deed Restrictions	Lump Sum				$1,000		$5,000		$1,000	$5,000
		Sub-total									*$1,000*	*$5,000*
		Total									*$13,600*	*$22,800*
		Contingency @ 10%									*$1,360*	*$2,280*
		Total Construction Costs									*$14,960*	*$25,080*
	3.0	ENGINEERING COSTS										
b	3.1	Closure documents	80	hrs	80	hrs	$80	/hr	$80	/hr	$6,400	$6,400
		Sub-total									$6,400	$6,400
		Total Estimated Capital Cost (1.0+2.0+3.0)									**$21,360**	**$31,480**

a) Means, 1996
b) Parsons ES Estimate

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O&M and Present Worth Calculations
Soil Alternative No. 3
Soil Cover

Activity	Quantity	Unit Rate	Low Estimate	High Estimate
Annual O&M costs				
Mowing and Inspection - semiannual	2 per year	$500	$1,000	$1,000
Repairs - Soil additions/spreading, reseeding, misc)	0.54 acre	$3,000	$1,625	$1,625
Present Worth O&M costs			*$2,625*	*$2,625*
Interest Rate	0.05			
Number of Years	30			
Present Worth Factor = ((1+i)^n)-1/ i(1+i)^n	15.37			
O&M Present Worth			***$40,358***	***$40,358***
Agency Reporting (1/ 5 years) Present Worth			***$278,200***	***$278,200***
Total Capital Costs			***$284,700***	***$318,326***
TOTAL ALTERNATIVE #3 COST			**$603,258**	**$636,884**

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CAPITAL COST ESTIMATE
SOIL ALTERNATIVE NO. 3
SOIL COVER

Source of Rates		Cost Component	Quantity Estimate		Unit Rate Low Estimate	Unit Rate High Estimate	Estimated Cost Low	Estimated Cost High
	1.0	**SOIL COVER**						
a	1.1	Mobilization/Demobilization	1		$25,000	$25,000	$25,000	$25,000
b	1.2	Cap Construction	28,290 sq ft		$2.22 /sq ft	$2.22 /sq ft	$62,804	$62,804
a	1.3	Sand/Soil Layer- Borrow and Delivery Cost (1.5' uniform thickess)	3,143 cubic yds		$4.00 /cubic yd	$12 /cubic yd	$12,573	$37,720
a	1.4	Topsoil Layer- Purchase and Delivery Cost (6" uniform thickness)	524 cubic yds		$6.00 /cubic yd	$15 /cubic yd	$3,143	$7,858
a	1.5	Vegetation (Seeding)	28,290 sq ft		$0.03 /sq ft	$0.05 /sq ft	$707	$1,415
		Sub-total					*$104,228*	*$134,797*
	2.0	**MISCELLANEOUS**						
a	2.1	Cap Construction Soil Testing/Sampling	10 samples		$50 /sample	$50 /sample	$500	$500
a	2.2	Trailer and Utilities	1 months		$1,000 /month	$1,000 /month	$1,000	$1,000
		Sub-total					*$1,500*	*$1,500*
		Total					*$105,728*	*$136,297*
		Contingency @ 10%					*$10,573*	*$13,630*
		Total Construction Costs					*$116,300*	*$149,926*
	3.0	**ENGINEERING COSTS**						
a	3.1	Engineering Management	1 lump sum	1 lump sum	lump sum	lump sum	$10,000	$10,000
a	3.2	Remedial Design Workplan	150 hrs	150 hrs	$80 /hr	$80 /hr	$12,000	$12,000
a	3.3	Design Plans/Specs	1 lump sum	1 lump sum	lump sum	lump sum	$50,000	$50,000
a	3.4	Bidding & Contracting	1 lump sum	1 lump sum	lump sum	lump sum	$15,000	$15,000
a	3.5	Oversight - 1 Month	1 lump sum	1 lump sum	lump sum	lump sum	$33,000	$33,000
a	3.6	Surveying	1 lump sum	1 lump sum	lump sum	lump sum	$2,000	$2,000
a	3.7	Closure documents	80 hrs	80 hrs	$80 /hr	$80 /hr	$6,400	$6,400
a	3.8	Support Plans (H&S, Permitting,etc)	350 hrs	350 hrs	$80 /hr	$80 /hr	$28,000	$28,000
a	3.9	Remedial Alternative Workplan	150 hrs	150 hrs	$80 /hr	$80 /hr	$12,000	$12,000
		Sub-total					*$168,400*	*$168,400*
		Total Estimated Capital Cost (1.0+2.0+3.0)					**$284,700**	**$318,326**

a) Parsons ES Estimate
b) GeoCon Estimate

O&M and Present Worth Calculations
Soil Alternative No. 4
In-Situ Solidification of Soil and Debris; Soil Cover

Activity	Quantity	Unit Rate	Low Estimate	High Estimate
Annual O&M costs				
Mowing and Inspection - semiannual	2 per year	$500	$1,000	$1,000
Repairs - Soil additions/spreading, reseeding, misc)	0.54 acre	$3,000	$1,620	$1,620
Present Worth O&M costs			*$2,620*	*$2,620*
Interest Rate	0.05			
Number of Years	30			
Present Worth Factor = ((1+i)^n)-1/ i(1+i)^n	15.37			
O&M Present Worth			***$40,276***	***$40,276***
Agnecy Reporting (1/ 5 Years) Present Worth			***$278,200***	***$278,200***
Total Capital Costs			***$1,770,263***	***$2,575,564***
TOTAL ALTERNATIVE #4 COST			**$2,088,739**	**$2,894,040**

CAPITAL ./ ESTIMATE
SOIL ALTERNATIVE NO. 4
IN-SITU SOLIDIFICATION OF DEBRIS AND SOILS; SOIL COVER

Source of Rates			Quantity Low Estimate		Unit Rate Low Estimate	Unit Rate High Estimate	Estimated Cost Low	Estimated Cost High
	1.0	**Site Prep**						
b	1.1	Mobilization/Demobilization	1 lump sum		$100,000.00 lump sum	$100,000.00 lump sum	$100,000	$100,000
b	1.2	Site Prep- Decon Pad, clearing , erosion barriers	1 lump sum		$30,000.00 lump sum	$50,000.00 lump sum	$30,000	$50,000
		Sub-total					*$130,000*	*$150,000*
	2.0	**IN SITU SOLIDIFICATION/STABILIZATION**						
a	2.1	Site Preparation	1 lump sum		$15,000 lump sum	$15,000 lump sum	$15,000	$15,000
b	2.2	Treatment Processing (2)	13,150 cubic yds	13,150 cubic yds	$35 /cubic yd	$15 /cubic yd	$460,250	$197,250
a	2.3	Portland Cement (0.5:1, 1:1)	6,575 cubic yds	13,150 cubic yds	$70 /cubic yd	$100 /cubic yd	$460,250	$1,315,000
a	2.4	Delivery to site (1)	6,575 cubic yds	13,150 cubic yds	$2.25 /cubic yd	$2.25 /cubic yd	$14,794	$29,588
a	2.5	Reagent Handling	6,575 tons	13,150 tons	$2.75 /ton	$2.75 /ton	$18,081	$36,163
		Sub-total					*$968,375*	*$1,593,000*
	3.0	**CLAY CAP**						
a	3.1	Mobilization/Demobilization	1		$25,000	$25,000	$25,000	$25,000
b	3.2	Cap Construction	28,290 sq ft	42,435 sq ft	$2.22 /sq ft	$2.22 /sq ft	$62,804	$94,206
a	3.3	Sand/Soil Layer- Borrow and Delivery Cost (1.5' uniform thickess)	3,143 cubic yds	4,715 cubic yds	$4.00 /cubic yd	$12 /cubic yd	$12,573	$56,580
a	3.4	Topsoil Layer- Purchase and Delivery Cost (6" uniform thickness)	524 cubic yds	786 cubic yds	$6.00 /cubic yd	$15 /cubic yd	$3,143	$11,788
a	3.5	Vegetation (Seeding)	28,290 sq ft	42,435 sq ft	$0.03 /sq ft	$0.05 /sq ft	$707	$2,122
		Sub-total					*$104,228*	*$189,695*
	4.0	**MISCELLANEOUS**						
a	4.1	Trailer and Utilities	2 months	4 months	$1,000 /month	$1,000 /month	$2,000	$4,000
		Sub-total					*$2,000*	*$4,000*
		Total					*$1,204,603*	*$1,936,695*
		Contingency @ 10%					*$120,460*	*$193,669*
		Total Construction Costs					*$1,325,063*	*$2,130,364*
	5.0	**ENGINEERING COSTS**						
a	5.1	Engineering Management	1 lump sum	1 lump sum	lump sum	lump sum	$40,000	$40,000
a	5.2	Remedial Design Workplan	300 hrs	300 hrs	$80 /hr	$80 /hr	$24,000	$24,000
a	5.3	Design Plans/Specs	1 lump sum	1 lump sum	lump sum	lump sum	$150,000	$150,000
a	5.4	Bidding & Contracting	1 lump sum	1 lump sum	lump sum	lump sum	$40,000	$40,000
a	5.5	Oversight - 4 Months	1 lump sum	1 lump sum	lump sum	lump sum	$100,000	$100,000
a	5.6	Surveying	1 lump sum	1 lump sum	lump sum	lump sum	$10,000	$10,000
a	5.7	Closure documents	120 hrs	120 hrs	$80 /hr	$80 /hr	$2,000	$2,000
a	5.8	Support Plans (H&S, Permitting, Air Mon.)	750 hrs	750 hrs	$80 /hr	$80 /hr	$60,000	$60,000
a	5.9	Remedial Alternative Workplan	240 hrs	240 hrs	$80 /hr	$80 /hr	$19,200	$19,200
		Sub-total					*$445,200*	*$445,200*
		Total Estimated Capital Cost (1.0+2.0+3.0+4.0+5.0)					**$1,770,263**	**$2,575,564**

a) Parsons ES Estimate
b) GeoCon Estimate

O&M and Present Worth Calculations
Soil Alternative No. 5

EXCAVATION OF SOIL AND DEBRIS; STABILIZATION/SOLIDIFICATION OF SOIL; BACKFILL TREATED SOIL AND DEBRIS: SOIL COVER

Activity	Quantity	Unit Rate	Low Estimate	High Estimate
Annual O&M costs				
Mowing and Inspection - semiannual	2 per year	$500	$1,000	$1,000
Repairs - Soil additions/spreading, reseeding, misc)	0.54 acre	$3,000	$1,620	$1,620
Present Worth O&M costs			*$2,620*	*$2,620*
Interest Rate	0.05			
Number of Years	30			
Present Worth Factor = ((1+i)^n)-1/ i(1+i)^r	15.37			
O&M Present Worth			***$40,276***	***$40,276***
Agency Reporting (1/ 5 years) Present Worth			***$278,200***	***$278,200***
Total Capital Costs			***$1,970,671***	***$3,239,756***
TOTAL ALTERNATIVE #5 COST			**$2,289,147**	**$3,558,232**

CAPITAL COST ESTIMATE
SOIL ALTERNATIVE NO. 5
EXCAVATION OF SOIL AND DEBRIS; SOLIDIFICATION OF SOIL; BACKFILL TREATED SOIL AND DEBRIS; SOIL COVER

Source of Rates	No.	Item	Quantity Low Estimate	Quantity High Estimate	Unit Rate Low Estimate	Unit Rate High Estimate	Estimated Cost Low	Estimated Cost High
	1.0	**EXCAVATION**						
b	1.1	Mobilization/Demobilization	1 lump sum	1 lump sum	$100,000.00 lump sum	$100,000.00 lump sum	$100,000	$100,000
b	1.2	Site Prep- Decon Pad, clearing, erosion barriers	1 lump sum	1 lump sum	$30,000.00 lump sum	$50,000.00 lump sum	$30,000	$50,000
a	1.3	Excavation	13,150 cubic yds	13,150 cubic yds	$15.00 /cubic yd	$40.00 /cubic yd	$197,250	$526,000
a	1.4	Debris Stockpile/Staging	7,900 cubic yds	7,900 cubic yds	$3.00 /cubic yd	$3.75 /cubic yd	$23,700	$29,625
		Sub-total					*$350,950*	*$705,625*
	2.0	**SOLIDIFICATION/STABILIZATION OF SOIL/ BACKFILL**						
a	2.1	Soil Stockpile/Staging	5,250 cubic yds		$3.00 /cubic yd	$3.75 /cubic yd	$15,750	$19,688
a	2.2	Erosion Control for Excavated Soils	10,000 sq ft		$0.96 /sq ft	$0.96 /sq ft	$9,600	$9,600
b	2.3	Treatment Processing	5,250 cubic yds	5,250 cubic yds	$15 /cubic yd	$15 /cubic yd	$78,750	$78,750
a	2.3.1	Portland Cement (0.5:1, 1:1)	2,625 cubic yds	5,250 cubic yds	$60 /cubic yd	$85 /cubic yd	$157,500	$446,250
a	2.3.2	Delivery to site	2,625 cubic yds	5,250 cubic yds	$2.25 /cubic yd	$2.25 /cubic yd	$5,906	$11,813
a	2.3.3	Reagent Handling	2,625 tons	5,250 tons	$2.75 /ton	$2.75 /ton	$7,219	$14,438
a	2.4	Backfill of Treated Soil and Debris	15,800 cubic yds	18,400 cubic yds	$10.00 /cubic yd	$25 /cubic yd	$158,000	$460,000
		Sub-total					*$432,725*	*$1,040,538*
	3.0	**SOIL COVER**						
a	3.1	Mobilization/Demobilization	1		$25,000	$25,000	$25,000	$25,000
b	3.2	Cap Construction (1)(5)	28,290 sq ft	42,435 sq ft	$2.22 /sq ft	$2.22 /sq ft	$62,804	$94,206
a	3.3	Sand/Soil Layer- Borrow and Delivery Cost (1.5' uniform thickess)	3,144 cubic yds	4,716 cubic yds	$4.00 /cubic yd	$12 /cubic yd	$12,576	$56,592
a	3.4	Topsoil Layer- Purchase and Delivery Cost (6" uniform thickness)	524 cubic yds	786 cubic yds	$6.00 /cubic yd	$15 /cubic yd	$3,143	$11,788
a	3.5	Vegetation (Seeding)	28,290 sq ft	42,435 sq ft	$0.03 /sq ft	$0.05 /sq ft	$707	$2,122
		Sub-total					*$104,230*	*$189,707*
	4.0	**MISCELLANEOUS**						
a	4.1	Soil Sampling (confirmatory from excavation)	35 samples	100 samples	$1,300 /sample	$1,400 /sample	$45,500	$140,000
a	4.2	Soil Sampling of Treated Material	50 samples	50 samples	$1,475 /sample	$1,700 /sample	$73,750	$85,000
a	4.3	Air Monitoring Equipment	1 lump sum	1 lump sum	$130,000 lump sum	$130,000 lump sum	$130,000	$130,000
a	4.4	Air Monitoring/Validation	5 months	5 months	$50,000 /month	$50,000 /month	$250,000	$250,000
a	4.5	Trailer and Utilities	4 months	4 months	$1,000 /month	$1,000 /month	$4,000	$4,000
		Sub-total					*$499,250*	*$605,000*
		Total					*$1,387,155*	*$2,540,869*
		Contingency @ 10%					*$138,716*	*$254,087*
		Total Construction Costs					*$1,525,871*	*$2,794,956*
	5.0	**ENGINEERING COSTS**						
a	5.1	Engineering Management	1 lump sum	1 lump sum	$40,000 lump sum	$40,000 lump sum	$40,000	$40,000
a	5.2	Remedial Design Workplan	300 hrs	300 hrs	$80 /hr	$80 /hr	$24,000	$24,000
a	5.3	Design Plans/Specs	1 lump sum	1 lump sum	$150,000 lump sum	$150,000 lump sum	$150,000	$150,000
a	5.4	Bidding & Contracting	1 lump sum	1 lump sum	$40,000 lump sum	$40,000 lump sum	$40,000	$40,000
a	5.5	Oversight - 4 Months	1 lump sum	1 lump sum	$100,000 lump sum	$100,000 lump sum	$100,000	$100,000
a	5.6	Surveying	1 lump sum	1 lump sum	lump sum	lump sum	$2,000	$2,000
a	5.7	Closure documents	120 hrs	120 hrs	$80 /hr	$80 /hr	$9,600	$9,600
a	5.8	Support Plans (H&S, Permitting, Air Mon.)	750 hrs	750 hrs	$80 /hr	$80 /hr	$60,000	$60,000
a	5.9	Remedial Alternative Workplan	240 hrs	240 hrs	$80 /hr	$80 /hr	$19,200	$19,200
		Sub-total					*$444,800*	*$444,800*
		Total Estimated Capital Cost (1.0+2.0+3.0+4.0+5.0+6.0)					**$1,970,671**	**$3,239,756**

a)Parsons ES Estimate
b) GeoCon Estimate

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O&M and Present Worth Calculations
Soil Alternative No. 6
Excavation, Disposal in E-Area Vaults or Consolidation Facility

Activity	Quantity	Unit Rate	Low Estimate	High Estimate
Annual O&M costs			$0	$0
Present Worth O&M costs			*$0*	*$0*
Interest Rate	0.05			
Number of Years	30			
Present Worth Factor = ((1+i)^n)-1/ i(1+i)^r	15.37			
O&M Present Worth			***$0***	***$0***
Total Capital Costs			***$16,074,376***	***$16,711,826***
TOTAL ALTERNATIVE #6 COST			**$16,074,376**	**$16,711,826**

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CAPITAL COST ESTIMATE
SOIL ALTERNATIVE NO. 6
EXCAVATION, DISPOSAL IN E-AREA VAULTS OR CONSOLIDATION FACILITY

Source of Rates	No.	Item	Quantity Low Estimate	Quantity	Unit Rate Low Estimate	Unit Rate High Estimate	Estimated Cost Low	Estimated Cost High
	1.0	**EXCAVATION**						
a	1.1	Mobilization/Demobilization	1 lump sum		$50,000.00 lump sum	$75,000.00 lump sum	$50,000	$75,000
a	1.2	Site Prep- Decon Pad, clearing, erosion barriers	1 lump sum		$30,000.00 lump sum	$50,000.00 lump sum	$30,000	$50,000
a	1.3	Excavation	13,150 cubic yds		$15.00 /cubic yd	$40.00 /cubic yd	$197,250	$526,000
		Sub-total					*$277,250*	*$651,000*
	2.0	**DISPOSAL**						
b	2.1	Transport	13150 cubic yds		$8.25 /cubic yd	$8.25 /cubic yd	$108,488	$108,488
c	2.2	Disposal	13,150 cubic yds		$1,026.00 /cubic yd	$1,026 /cubic yd	$13,491,900	$13,491,900
		Sub-total					*$13,600,388*	*$13,600,388*
	3.0	**MISCELLANEOUS**						
a	3.1	Soil Sampling (confirmatory from excavation)	35 samples	100 samples	$1,300 /sample	$1,400 /sample	$45,500	$140,000
a	3.2	Soil Sampling of Treated Material	50 samples	50 samples	$1,475 /sample	$1,700 /sample	$73,750	$85,000
a	3.3	Air Monitoring Equipment	1 lump sum	1 lump sum	$130,000 lump sum	$130,000 lump sum	$130,000	$130,000
a	3.4	Air Monitoring/Validation	2 months	4 months	$50,000 /month	$50,000 /month	$100,000	$200,000
a	3.5	Trailer and Utilities	2 months	3 months	$1,000 /month	$1,000 /month	$2,000	$3,000
		Sub-total					*$349,250*	*$555,000*
		Total					*$14,226,888*	*$14,806,388*
		Contingency @ 10%					*$1,422,689*	*$1,480,639*
		Total Construction Costs					*$15,649,576*	*$16,287,026*
	4.0	**ENGINEERING COSTS**						
a	4.1	Engineering Management	1 lump sum	1 lump sum	lump sum	lump sum	$40,000	$40,000
a	4.2	Remedial Design Workplan	300 hrs	300 hrs	$80 /hr	$80 /hr	$24,000	$24,000
a	4.3	Design Plans/Specs	1 lump sum	1 lump sum	lump sum	lump sum	$150,000	$150,000
a	4.4	Bidding & Contracting	1 lump sum	1 lump sum	lump sum	lump sum	$20,000	$20,000
a	4.5	Oversight - 4 Months	1 lump sum	1 lump sum	lump sum	lump sum	$100,000	$100,000
a	4.6	Surveying	1 lump sum	1 lump sum	lump sum	lump sum	$2,000	$2,000
a	4.7	Closure documents	120 hrs	120 hrs	$80 /hr	$80 /hr	$9,600	$9,600
a	4.8	Support Plans (H&S, Permitting, Air Mon.)	750 hrs	750 hrs	$80 /hr	$80 /hr	$60,000	$60,000
a	4.9	Remedial Alternative Workplan	240 hrs	240 hrs	$80 /hr	$80 /hr	$19,200	$19,200
		Sub-total					*$424,800*	*$424,800*
		Total Estimated Capital Cost (1.0+2.0+3.0+4.0)					**$16,074,376**	**$16,711,826**

a) Parsons ES Estimate
b) Means, 1996
c) SRS Estimate

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APPENDIX B
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